

INTEGRATING STATISTICS: DOING RESEARCH IN UNDERGRADUATE STUDIES

FERRÃO, Maria Eugénia

University of Beira Interior and CEMAPRE,
Portugal

Contact email: meferrao@ubi.pt

Abstract

The paper describes the project Mathematics and Statistics for the Development of Professional Skills. Motivation and integration are keywords of teaching statistics to students who are not primarily interested in statistics. The motivation is based on illustrative problems, questions or examples of the field and real life that can be solved, answered or better understood with the study of the respective statistical content(s). Recently published scientific papers are used as didactic material. In general, the integration occurs throughout the following steps: explaining abstract statistical concepts and methods; applying concepts and methods to the example given as motivation; doing tutorial data analyses with statistical software; replicating data analyses and solving research problems with real data. The pedagogic methodology is based on the mixed uses of lectures and student centered activities. The didactic method exposed allows students an early practice of scientific activities.

Key words: *statistics education; research training; teaching methodology; higher education*

1. INTRODUCTION

The project Mathematics and Statistics for the Development of Professional Skills aimed at adapting to a new culture of teaching, learning and assessment in the context of the Bologna Declaration, and at the same time, to enlighten the adoption of new methods and practices which could assure high standards of quality in higher education. Moreover, it was an excellent opportunity to follow the recommendation of the American Statistical Association, according to which “[...] the time is right to build stronger emphases on education statistics in colleges and universities, and to do so in a way that builds a solid infrastructure for long-term development. We hope that education departments and statistics departments, among others, can join forces in these efforts” (Scheaffer & Smith, 2007; p. 44).

The project was designed to be composed by two components: the first called *The modularization and harmonization of curricular contents*, and the second called *E-assessment in higher education*. The second component was planned and implemented with the financial support of the Ministry of Science, Technology and Higher Education (Action IV.1.2 – Qualification on Higher Education, Innovative Research Projects, reference code: POCI/C/04.01.02/0155/0001/200) and it is partly described by Ferrão (2010). The first component had two main objectives: 1) to update statistics and mathematics curricular plans at the bachelor degree, keeping in mind the recent change in the core curriculum at secondary education level and the need to open up higher education to new and more heterogeneous population; 2) to prepare didactic material for the development of the professional skills. The project was focused on statistics and mathematics with the cumulative purpose of contributing to the improvement of the success rate in those units, and also with the purpose of allowing students individual flexible working plans (as foreseen by the Portuguese law).

The project was strongly influenced by António Sérgio’s thoughts. Sérgio (1915, pp.91-92) tells us about the teacher’s role as the one who must set the conditions to awaken the deep motivation to get students interested in and show them the way to learn and to satisfy such interests and motivation, appealing for students’ effort and advising on the teaching and learning conditions, which must be as close as possible to the real adult life. His thoughts were on the vanguard of the lessons given by educational researchers nowadays, and they may be synthesized by two key words: “motivation” and “integration”. In the following sections a brief review of the literature on the demands of statistics curriculum in higher education and an overview of specificities of statistics education are presented. Finally, the description of the practice case of

statistics education throughout the motivation and integration of scientific knowledge in psychology, conducted at the University of Beira Interior in the academic year 2011/12.

2. A CASE OF STATISTICS EDUCATION IN PSYCHOLOGY

2.1 *A synthesis of the curricular plan*

The 1st cycle (bachelor) degree in psychology includes two units of statistics applied to psychology, each one 64 hours long (equivalent to 6 ECTS credits), that take place over the 1st year of studies. It is expected that students become able to apply statistical methods and techniques to real data analyses using statistical software; to analyze studies that include quantitative methods related to statistical inference; to search scientific knowledge in psychology related to applied statistical methods; to produce technical reports using statistical results; to develop his/her own research; to integrate interdisciplinary project teams.

2.2 *Statistical skills developed at high school and material requirements*

It is assumed students had attended the course of Applied Mathematics to Social Sciences offered in the Portuguese upper secondary education level (Silva, Martins, Martins, & Loura, 2001) in such a way that the prerequisites for the development of intermediate level of statistical analyses are satisfied.

UBI provides the material and physical environment such as the appropriate conditions for learning activities are met. There is a computer with statistical software for each group of three students; the statistical license software is extensible to every student's laptop over a year; a web platform supporting the learning activities, that is for example a repository of teaching notes, of databases and technical reports, of formative and summative assessment instruments, etc.; adequate library resources and online journals access (*b-on*); equipped teaching spaces and lecture rooms with the adequate presentational equipment.

3. INTEGRATING STATISTICS TO PSYCHOLOGY

The project *Mathematics and Statistics for the Development of Professional Skills* was mentored according to the thoughts that involvement in current state-of-the-art research is a valuable contribution towards good teaching and that research of any kind is essentially the systematic and informed search for the research answers, making sense of data to explain the findings to other people (Race, 1995). In this way, teaching statistics to beginner psychology learners using research methodology and scientific knowledge may be seen as a pedagogical approach that simultaneously attend all the general and specific objectives of both curricular units. Two main phases may be identified: the motivation and the integration.

The use of scientific papers or reviews published in international refereed journals as a source of motivation for the introduction of a topic in statistics, i.e. the research question is presented and explained, and the statistical method or technique used in the paper is identified. A lecture is given on the conceptual and theoretical contents involved, and a practical situation is given as well. Whenever possible the motivation example is adapted for problem-solving and/or data analyses.

One of the outcomes delivered by each group of students, as a team, is a technical report describing their research activity on a topic given and using methods previously chosen. Even though some of the tasks do not require a great deal of time to complete, students are encouraged to write a report on their findings. For this achievement, a mixture of teaching methods was used.

In the academic year 2011/12 seventy students were enrolled, split into two shifts. The topic for research was motivated by Lopes (2011). The author uses chi-square independence tests to explore her research questions on social representations. This was the starting point. Professor Luís Pardal made available the database on teachers' social representations (Pardal, Gonçalves, Martins, Neto-Mendes, & Pedro, 2011; Sousa, Pardal, & Villas Boas, 2009) and Professor Manuel Loureiro was invited to give a seminar on the foundational concepts of social psychology.

3.1.1 *The data*

The target population consists of higher education students who attended a training course for teachers of pedagogy/elementary school teachers or teachers taking their degree in education, in Argentina, Brazil and Portugal in 2006/2007. The sample size is 2,789 and the survey questionnaires are presented by Pardal et al. (2011; pp.122-125).

3.1.2 *The research questions*

Some of the research questions raised in class are the following:

- a) Is there empirical evidence of a social representation existence as a Teacher-Psychologist representation?
- b) Is there any other related representation based on the belief that a relationship among teacher and student is fundamental in overcoming learning difficulties?

3.1.3 *The statistical contents in practice*

The statistical contents used are the following: descriptive statistics, contingency tables, probability distributions (marginal, joint and conditional probabilities), odds ratio, non-parametric correlation, chi-square independence test, and logistic regression. Frequency tables allowed the sample characterization such as presented by Pardal, Albuquerque, Lopes, & Ferrão (2012a). Contingency tables were used to calculate marginal, joint and conditional probabilities, the odds ratio, non-parametric correlation coefficients such as the coefficient of contingency and the Cramer coefficient (see Pardal et al., 2012a). Authors also applied the chi-square hypotheses test for the independence between Y (learning strategy chosen) and X (social representation Professor-Psychologist). The results obtained suggest that “[...] At level of significance of 5% the null hypothesis is rejected since $\chi^2=4.587$, p-value=0.032, $\chi^2_{(\alpha=0.05;df=1)}=3.84$. Thus, there is statistical evidence that variables Y and X are not statistically independent at the level of significance of 5%”. The logistic regression model, hypotheses test for the model parameters, and odds ratio were applied in order to study the relationship between Y and X, according to the example presented in Pardal, Albuquerque, Lopes, & Ferrão (2012b).

Many other scientific contributions published in refereed journals were used in class. Table 1 contains some examples and the respective statistical contents.

Table 1. Papers used in class

Reference	Statistical contents in practice
(Avanci, Assis, Oliveira, Ferreira, & Pesce, 2007)	Logistic Regression; Odds ratio.
(Ferrão, 2012)	Correlation and causality.
(Lopes, 2011)	Chi-square hypotheses test for the independence between variables.
(Loureiro et al., 2011)	Scales and variables. Confidence intervals; hypotheses test for the mean. Contingency tables; non-parametric correlation; chi-square hypotheses test for the independence between variables.
(Morgan & Saffran, 1995)	Hypotheses test: paired samples t-test.
(Peixoto & Almeida, 2011)	Scales and variables.
(Pratta & Santos, 2007)	Odds ratio. Confidence intervals.
(Primi & Almeida, 2000)	Correlation.
(Primi, Ferrão, & Almeida, 2010)	Scales and variables; measurement. Descriptive statistics. Correlation.
(Robinson, 1950)	Correlation and ecological fallacy.
(Soares, Fernandes, Ferraz, & Riani, 2010)	Linear regression model.
(Steinberg, Cauffman, Woolard, Graham, & Banich, 2009)	Descriptive statistics. Hypotheses tests.
(Suehiro, Rueda, Oliveira, & Pacanaro, 2009)	Scales and variables.
(Young, 1991)	Contingency tables; non-parametric correlation; logistic regression. Nominal variables as explanatory variables in the logistic regression.

4. FINAL REMARKS

The goodness of the pedagogic approach described in the paper emerges from the students' commitment in class. It has not been assessed by scientific methods yet. Further work is necessary to give evidence that, in the short term, the use of tasks scientifically based constitute a positive approach for the students' engagement in statistics learning.

The pedagogic approach may be undermined if there is a large proportion of students in class who do not satisfy the prerequisites. Facing this situation, more procedural oriented tasks must be delivered in order to overcome that obstacle.

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