ENVIRONMENTAL INTERFACES IN TEACHING STATISTICS

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The objective of this article is, based on the Critical Statistics Education assumptions, to value some environmental interfaces in teaching Statistics by modeling projects. Due to this, we present a practical case, one in which we address an environmental issue, placed in the context of the teaching of index numbers, within the Statistics discipline in an undergraduate course in Economic Sciences. In this project, we discuss the Human Development Index (HDI) and we propose the creation of an environmental index in order to evaluate the countries concern level in following some ecological and/or preservation practices.

INTRODUCTION

Political awareness and the discussion of social issues related to student's reality are the main goals of Critical Education (CE) at any schooling level. In our view, as in the opinion of the main organizers of this theory, such a goal can be pursued regardless of the syllabus of the subjects. We understand that educators can build adaptations to embrace themes that facilitate discussion of social-political issues which are relevant to the student's reality.

Critical Statistics Education (CSE), as presented by Campos (2007), by connecting the fundamentals of Statistics Education (SE) and CE shows, through mathematical modeling, the possibilities of integration and combination of objectives among these pedagogical approaches.

In this context, we present a fragment of CSE's theoretical basis and show, through a mathematical modeling project, how it is possible to achieve positive results with this integration.

CE, SE, AND CSE

As a development of critical thinking, CE has emerged in opposition to traditionalism in the educational system, and its foundations can be credited mainly to Jurgen Habermas ,in Germany, and Paulo Freire in Latin America. Freire's work, which proposes emancipatory ways of knowledge, had inspired Giroux (1997), who extended the idea of democratization and politicization of education, within a vision of the teacher as an intellectual transformer: "essential for the category of intellectual transformer is the need to make the pedagogical more political and the political more pedagogical" (p. 163), in such a perspective from which "critical reflection and action become part of the fundamental social project to help students to develop a deep and abiding faith in the struggle to overcome economic, political, and social injustices and further humanize themselves as part of this struggle" (ibid., p. 163).

Skovsmose, in turn, incorporated these concepts and progressed in the development of CE. He stated that "it is essential that the issues relate to fundamental social conflicts and situations and it is important that students can recognize problems as their own problems" (Skovsmose, 2004, p. 24). Centered around the democracy question, Skovsmose worked towards a Critical Mathematics Education, in which working with modeling projects is valued.

Mainly developed since the 1990s, SE was conceived in an unease context, trying to question and reflect over problems related with the teaching and learning of this discipline. This education was ignited by the difficulties that students have in thinking or reasoning statistically even when they show calculation skills. Seeking to differentiate the pedagogical problems presented by Statistics from those presented by the teaching of Mathematics, several authors converged on the idea that the teaching of Statistics should focus on the development of three specific skills: statistical thinking, statistical reasoning, and statistical literacy.

Statistical literacy has been well characterized by Gal (2004), who emphasized two interrelated components:

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a) people's ability to interpret and critically evaluate statistical information, arguments relating to data from research and stochastic phenomena found in different contexts;
b) people's ability to discuss or communicate their reactions to this statistical information, along with their interpretations, opinions, and understandings.

Statistical thinking is linked to the idea of evaluating the statistical problem globally, understanding how and why statistical analyses are important. Thus, statistical thinking is related to the ability to identify statistical concepts involved in the investigations and problems dealt with, including the nature of data variability, the uncertainty, how and when to properly use the methods of analysis and estimation, etc. According to Chance (2002), this capacity provides the student to have the ability to explore the data in order to extrapolate what is given in the texts and to generate new questions beyond those indicated in the research.

The way in which people reason with statistical concepts composes what is generally called statistical reasoning. According to Garfield (2002), to reason statistically means doing appropriate interpretations of a certain data set, to correctly represent or summarize the data, to make connections between the concepts involved in a problem, or to combine ideas involving variability, uncertainty, and probability. The development of statistical reasoning should lead the student to be able to understand, interpret, and explain a statistical real data based process. Ben-Zvi (2008) emphasizes the importance of this capability. He states that all citizens should have it and that it should be a standard ingredient in education.

In order to develop these competences in students, Campos (2007) suggests:

- work with real data and relate it to the context in which it is involved;
- encourage students to interpret, explain, criticize, justify, and evaluate the results, preferably working in groups, discussing and sharing opinions.
- In order to address CE's major aspects, Campos, Wodewotzi and Jacobini (2011) suggest:
- problematize teaching, work on Statistics through contextualized projects within a reality consistent with the student's;
- promote debates and dialogues among students and between them and the teacher, assuming a pedagogical democratic attitude;
- thematize the teaching by prioritizing activities that enable the discussion of important social and political issues;
- use technology basis in teaching, valuing skills of instrumental character;
- adopt a flexible pace for developing the themes;
- discuss the curriculum and the pedagogical structure adopted.

By adopting these actions in the educational process, we will be practicing a CSE that goes against the traditional teaching model. In this context we have defended (Campos, 2007 and Campos, Wodewotzi & Jacobini, 2011) that working with mathematical modeling projects comprises an appropriate pedagogical strategy, as it consists in an efficient way to articulate theory and practice and favors the breakup of arbitrary boundaries between disciplines, allowing a broader and more effective scope.

ENVIRONMENT DESCRIPTION

In the Statistics discipline, taught in an Economic Sciences course by the first author of this paper, one of the program contents is Economic Indices, which include index numbers and others socioeconomic indices, like GNI per capita, infant mortality, etc. In this class, we approach the Human Development Index (HDI), which aggregate three sub-indices: an income index, a health index and an educational index. Discussing the wideness of this index, we criticize the fact that it doesn't include indicators which could evaluate questions like religion liberty, communication liberty and free govern choices. The students pointed out the fact that HDI doesn't include an environmental index that could measure the preservation level of a country. As this is a controversial subject and has generated much debate, we proposed an activity be held related to this theme, organizing groups, and selecting topics for each group to prepare a presentation.

The students chose the following topics in order to research and make a presentation:

- Recycling and reuse: economic impacts
- Sustainable cities
- Economic consequences of global warming
- Socio-environmental responsibility in companies
- Green economy
- Environmental index

The five first groups did presentations and delivered reports which didn't refer specifically to Statistics but focused in socio-economical and environmental aspects. Nevertheless, presentations embraced graphics and tables in order to represent real data.

Concerning to the environmental preservation índex, the group adopted the old calculation methodology of HDI, that is, an index that goes from 0 to 1, which is calculated by the formula:

$$I_i = \frac{X_i - MIN(X_i)}{MAX(X_i) - MIN(X_i)}$$

Where:

I = index of the referred variable

X = observed value of the variable

MIN (X) and MAX (X) are the lowest and highest values the variable X can attain, respectively.

Beyond this formula, the group explained that some sub-indices would be represented as percentages. Thus, the group proposed to calculate several sub-indices:

I_1) sewer treatment index: it measure the percentage of launched sewer treat in the environment in relation to the total produced sewer;
I_2) gases launching index that provoke greenhouse effect, calculated by the DHI formula;
I_3) atmospheric pollution index of the great cities, calculated by the DHI formula;
I_4) native vegetal covering preservation index, calculated by the DHI formula;
I_5) beaches balneability index, given by the improper beach percentage for the bath due to pollution in relation to the total number of beaches;
I_6) recycling index, given by the percentage of effectively recycled materials;
I_7) energy index, given by the percentage of the total energy matrix that comes from clean and renewable sources;
I_8) animal species preservation index, given by the number of extinguishing threatened animal species of the local fauna, calculated by the HDI formula.

The aggregated environmental preservation índex should be calculated by the simple arithmetic mean of the sub-indices. The country is more engaged in environmental preservation as the result gets closer to 1.

In the debates, students seems to be infuriated with the fact that an environmental preservation index officially doesn't exists and they argued divulging forms to lead this information to the general population.

ANALYSIS

In this project, the worked statistics content was the an index calculation. The group that presented this subject detailed the calculation methodology, creating a simple and objective index. This process contributed to deepen the students knowledge on this kind of calculation.

Relating to the three capacities mentioned by the SE's theoretical beddings, we observe that the work with real situations involved in the index calculation allowed the pupils to have a global view of the problem. Students had been able to perceive the difficulties that surround the complexity of this index and had followed some statistical tools used in its determination. We understand that this work tends to help the development of the statistical thinking and the statistical reasoning on data and measures. Due to literacy, we believe that the reports construction, the use of

statistics typical expressions and terminologies, the elaboration work of the presented graphs and tables, as well as the quarrels involving the environment preservation index thematic tends to assist the development of this competence.

Due to the CE, we understand that in some aspects we had it in eminence. At several moments the pupils had been faced to the ambient degradation problem and its consequences. The debates had shown a repudiation and revolt feeling to the indifference situations that had been shown. Moreover, the pupils had argued forms of fighting the ambient degradation problem and the possible actions towards it.

Due to the CSE, we perceive that throughout the project we had been in the way traced for the theoretical considerations foreseen by Campos, Wodewotzki and Jacobini (2011), as we followed most of the suggested attitudes for the work in classroom, mentioned here.

CONCLUSION

In the execution of the pedagogical activities related to the project that we describe here, we had the objective of showing a possibility of insertion of CSE inside a content of Statistics discipline in a graduation course. In this context, we had tried to emphasize the social political interfaces involved in the suggested thematization, that emerged from the pedagogical environment lived by the professor. Our interest when telling this experience was to show that the opportunities of insertion of a thematic related to the social and political problems occur at several moments at the pedagogical action. We understand that it is up to the educator to take advantage of these situations in order to stimulate the critical, investigative and contester spirit of the students which stands out when they face a social problem which involves their reality.

We believe that, without losing the focus on the statistical contents, when adopting the CSE we can excessively enrich the pedagogical process due to give the student the chance to better understand his own reality. Thus, he can find the ways to carry out actions which really represent reactions against the unjust and sometimes immoral system in which he lives. Due to this, we understand that the professor carries through a much more encircling role and makes education most significant, more interesting and truer.

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