STATISTICS EDUCATION IN THE CONTEXT OF THE CRITICAL EDUCATION: TEACHING PROJECTS

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Statistics Education researchers identify the development of three competences: statistical literacy, thinking and reasoning as relevant in teaching and learning of Statistics. These competences are linked to an education aimed at the formation of critical citizenship, which is in accordance to the principles of Critical Education. In this article we present three projects where this combination of goals is explored. The contents of Statistics are linked to discussions about social and political problems; students work with real data relating them to the context which they are part of, understand the results, criticize and discuss ideas, and work in groups. Hence we encourage the development of the three competences above, together with the principles that surround Critical Education. Consequently, we see that Statistics Education and Critical Education interact and complement each other, showing harmony of purposes, which is favorable to a truer education.

INTRODUCTION

Several thinkers question the purpose of Mathematical Education, reflecting on the pedagogical reason for Mathematics. These reflections involve democratic positions, social-economical-cultural matters, and constant dialogues on citizenship along with the elimination of preconceptions of the nature of the relationship of the power structure in the relation between the professor and his pupils, similar to the relation of the pupils between each other (Jacobini & Wodewotzki, 2006). Skovsmose (2007) is one of the most important proponents of this set of educational attitudes, which has to do with the concepts of Critical Education in the mathematical teaching-and-learning process.

In a similar way, in the scope of Statistics Education, we observe growing concern with the development of an investigative, reflective and critical attitude of the student in a globalized society, highlighted by the accumulation of information and the necessity of making decisions in situations of uncertainty.

Thus, it is important in the Statistics teaching and learning process that the development of three abilities related to each other: the statistical literacy, thinking and reasoning are based on the critical interpretation and understanding of information derived from real data. Thus this process is associated with an education resulting in the formation of a critical citizenship and hence finds itself in agreement with the principles of the Critical Education. In this article we approach the interaction between the main ideas of Critical Education and Statistics Education by presenting some education projects developed at university courses.

THE STATISTICS EDUCATION IN THE CONTEXT OF CRITICAL EDUCATION

According to Critical Education, the professor and his pupils accept and assume the role of investigators interested in matters that are related to the social reality of their environment. Thus creating possibilities for the construction of the knowledge and carrying through intellectual activities consisting of inquiries, consultation and criticism. The professor and his pupils become aware of the social aspects that are always present when working with daily problems. Thus they involve themselves with the community, by transforming reflections into action. It is in this context of a critical-education classroom that we design our Statistics Education.

Our Statistics Education shows itself as an evolving science. In such a way, it incorporates gradual changes in the point of view of its content and also its formation demands (Campos, 2007), once the necessity of interpretation of real-data-based information is more frequent and the education for the citizenship goes necessarily through a critical understanding of this pack of information.

Researchers such as Chance (2002), Gal (2004), Garfield and Ben-Zvi (2008), Rumsey (2002) and others identify in their studies some problems in Statistics teaching. They argue that the

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instruction planning must tend to the development of three important competences: statistical literacy, statistical thinking and statistical reasoning, without which it would not be possible to learn the basic concepts of this discipline. These competences can be incorporated in a unified way and they can also be connected to the principles of Critical Education, because they present convergent ideas in several aspects.

A common aspect in the development of the three competences is that the interpretation of the Statistics information is only possible with the understanding of the source of the data. Another common point is that, in accordance with the named authors, these competences cannot be developed by direct instruction of the educators. Therefore, we understand that the professors can guide the learners to favor the experience of these capacities and its continuous improvement.

Thus, we identify some actions with the objective of developing the pupil's statistical competences (Campos, 2007). These are to work with real data, to relate the data to the context of its origin, to guide the pupils so that they interpret their results, to allow the students to work in groups in such a way that they criticize each other interpretations and to promote judgment about the conclusions they reached.

These actions are in accordance with the ideas of Critical Education (Campos, 2007): promote a problematized education, stimulate the pupil's creativity and reflection, promote the critical insertion of the student in the reality where he lives, valorize the political aspects involved in education, democratize education, promote a less hierarchical relationship between students and educators, encourage work in groups, develop social relationships, fight students' alienation, defend ethics and social justice, promote dialogue, individual freedom, and students' social responsibility.

The theoretical aspects raised in the studies about the Statistics Education seem to be in agreement with these Critical Education principles. In this way, we can search for a convergence of objectives, looking for strategies that favor both aspects, which in our understanding complement each other. Thus, we understand that the objective of teaching Statistics must always be followed by the objective of developing criticism and involvement of the students in the relevant social and politics manners for their life as citizens who live in a democratic society and fight for social justice in a humanized and engaged environment.

In order to show this interaction, we developed three projects that intend to promote the ideas and attitudes of Critical Education, as well as develop the competences identified by the Statistics Education researchers' authors.

Project 1: The disarmament of the Brazilian population

In 2005 a popular countersignature about the prohibition of weapons and ammunition commercialization took place in Brazil. It motivated one project that was divided in two stages. In the first stage, the pupils increased their knowledge of Plebiscites, Countersignatures and the Brazilian legislation about armaments. They analyzed results of opinion polls about this subject and studied the procedures and concepts adopted in these sample surveys. In the second stage, the pupils made a sample survey for University students in order to learn their opinion about this subject. In their reports the pupils analyzed the answers of college students and compared them with the information from the polls. Along with the construction of their knowledge, the students exerted reflections that identified the development of political awareness that was shown by their participation in a debate about the Disarmament subject organized at the University.

This project was developed throughout six months with students in the Statistics class of a Computing Engineering course, at a private university in Campinas-SP.

Project 2: The Statistics and the stock market

The students were motivated by their interest in the announced profits in stock exchange operations. We proposed a modeling assignment to make a technical study of stock market behavior. The pupils choose some stocks and calculated the average return, given by the arithmetic mean of the daily returns of a stock at a given period of time, the risk of a stock, given by the standard deviation of the daily returns, and the beta coefficient, given by the quotient between the covariance of an asset in relation to the market investments index and the variance of the market investments index. Later, through procedures of linear regression analysis, they built the mathematical function which expressed the stock price as a function of time (in days) with the help

of Excel spreadsheet features. Then, virtual operations of purchase and sale of stocks were accomplished by the students, based on strategy decisions created by them. At the end of the project a debate was carried out in which we discussed with the students social reality aspects, subjects such as the capitalism and its hunger for profits, the meaning of buying stocks of a company such as Taurus (weapons), Souza Cruz (cigarette) and Ambev (alcoholic beverages). Other debates dealt with unemployment and the students' professional development.

This project was developed at the last year of an Economic Sciences course at a private college in the city of São Paulo. The project took eight months and was inserted in the Economic Statistics discipline, whose program usually concludes with the econometrical regressions. The debate about unemployment started because of an argument in an article published in a major national circulation magazine, which explored the fact that the robots managing investment funds (computational programs) were performing better than humans managing them.

Project 3: The Chi-square Test

When approaching the content of chi-square test for independence or association of qualitative variables, we observe that the examples considered in the didactic books were few or not related to the pupils' reality. Nor did they even contain real data. Thus, to develop this project, the pupils debated controversial subjects, such as death penalty, the decriminalization of abortion, the liberalization of marijuana, the civil-union regulation between people of the same sex, the use of human embryos in cell- stem research, euthanasia, etc. They discussed what would be the associated variables to each subject and, later, organized in groups, that a specific subject to investigate. They collected data, performed data tabulation and analyzed inferences. Finally, each group wrote a report on the researched data and made a presentation in the classroom on the researched subject and the achieved results. The groups gave their opinions about the researched subjects and also stimulated debates in the classroom about each subject. The project execution went, beyond the calculation of the chi-square and its hypothesis test, to include the sampling problems associated with such a study.

This project was developed throughout two months, inside the Economic Statistics Introduction discipline, in the 3rd year of an Economic Sciences course, at a private college in the city of São Paulo. The program contents of this discipline usually conclude with the hypothesis tests.

CONCLUSION

First, we must point out that the statistical contents in these three examples were developed as each project progressed. Besides, we did not look for giving priority to the exercises lists for the pupils with these projects, but to involve themes of social relevance in the development of the statistical contents.

It is also important to observe that, with these projects, we were not interested in a quantitative analysis of the learning level of the statistical contents. Our analysis focused on the qualitative participation of the pupils in the worked subjects, detaching the increasing of the capacities (literacy, statistical reasoning and thinking) from the Critical Education.

As we pointed out, Statistics Education praises the development of statistical literacy, statistical thinking and statistical reasoning. These capacities can be stimulated through several actions, such as to work with real data, relate the data to the context where it originated interpret the results, criticize and debate related ideas and interpretations, allow work in groups, etc. All of these actions have been highlighted in the three projects presented above. The students were in charge of obtaining the data, outside the classroom. The data collection, as well as the work with the respondents, had relevance for the students as they were related to their social environment context; the students made written and oral reports of the results, presented their interpretations and debated the subjects, by defending their points of view and arguing their analyses. Thus, the three capacities that Statistics Education praises were deeply experienced and developed:

a) statistical literacy, as the information and the statistics language were set in a non-technical discussion context, valorizing questioning attitudes in which the students used the statistics as evidence in their opinions;

b) statistical thinking, as the data were related to concrete applied situations, by emphasizing that the results reveal a trend and not a certainty, interpreting the results and evaluating the problem in a global way, inquiring its reasons and exploring the data under different points of view; and
c) statistical reasoning, as the resulting information based on the students' collected data are interpreted and represented in the forms of graphs and tables, as there was a discussion about the relation between the samples and the population, and as the students are guided to relate and to interpret the worked variables and statistics.

Concerning Critical Education, we notice that the three projects are related to problems found in students' daily lives, both as a professional or as a citizen. The teacher, as well as the pupils, assumed, in the projects, the role of investigators interested in relating the statistical problems to the social contents of their environment and constructing knowledge as they carried on critical intellectual activities. The projects valorize the critical insertion of the students in their social reality, by debating this reality in order to have a better understanding of the world, by linking political aspects involved, by adopting democratic attitudes, by sharing experiences and results, by performing collective and collaborative works, by fighting hostile attitudes, and by emphasizing the dialogue, ethics, justice and the social responsibility of the learners.

Thus, we see that Statistics Education and Critical Education interact and complement each other in the work with these projects. They show a harmony of intentions and a conjugation of objectives, so that is highly favorable to the execution of a *truer education*, as we evidence the active role of the students in the pedagogical process and in realistic complex situations where they need to compromise, act democratically and work together.

This education is important because it values the student, once it stimulates him to look at himself and at the world around him, because it guides him to know and to share the social and political problems of the reality he lives in. It also guides him to question such reality and this questioning brings in itself an uncomfortable feeling and stimulates a reaction in order to change, to improve, and to demand ethical positions and attitudes, compromised with the welfare of the people and country.

We felt that the Critical Education was highly positive for us. As we changed our vision of education and we started to incorporate the democratic and questioning attitudes in our daily school hours so that we stimulated it in the students, we believe that we have been contributing for the construction of a better world.

REFERENCES

Campos, C. R. (2007). *A Educação Estatística: uma investigação acerca dos aspectos relevantes à didática da Estatística em cursos de graduação*. Tese de doutorado. Rio Claro, SP: UNESP.

Chance, B. L. (2002). *Components of statistical thinking and implications for instruction and assessment. Journal of Statistics Education*, *10*(3).

Gal, I. (2004). Statistical Literacy: Meanings, Components, Responsibilities. In D. Ben-Zvi & J. Garfield (Eds.), *The Challenge of Developing Statistical Literacy, Reasoning and Thinking* (pp. 47-78). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Garfield, J. B., & Ben-Zvi, D. (2008). *Developing students' statistical reasoning*. New York: Springer.

Jacobini, O. R., & Wodewotzki, M. L. L. (2006). *Uma reflexão sobre a modelagem matemática no contexto da Educação Matemática Crítica*. *Boletim de Educação Matemática* (BOLEMA), Rio Claro, UNESP, 25, 71-88.

Rumsey, D. J. (2002). Statistical literacy as a goal for introductory statistics courses. *Journal of Statistics Education*, *10*(3).

Skovsmose, O. (2007). *Educação Crítica: Incerteza, Matemática, Responsabilidade*. São Paulo: Editora Cortez.