Two activities to improve statistics courses for future mathematics teachers

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Abstract

The Statistics teaching in middle and high schools is part of the discipline of mathematics. Good preparation for future mathematics teachers is an important strategic action to enhance the presence of statistics in the society. A challenge to be faced is to improve the quality of statistics education offered in colleges and universities that are preparing these teachers. We present in this article some activities used in an introductory course for Mathematics Education degree of the Institute of Mathematics and Statistics, University of São Paulo, Brazil. We also discuss quantitative results comparing different editions of the course. The activities developed appear to have contributed to better student learning.

Keywords: mathematics teacher; basic statistics courses; statistics preparation

1. Introduction

In Brazilian middle and high schools, mathematics teachers are responsible to work with statistics concepts as part of mathematics curriculum. Mathematics Education degree includes one or two statistics courses, however, in several colleges and universities their quality is poor. They do not provide teachers an educational environment that might propitiate them confidence to teach statistics issues.

Concerning the contents of probability and statistics included in Brazilian Mathematics Education programs, Silva (2011) studied seven institutions that offered that degree. The author criticized the way these disciplines are offered without a specific connection with the content of regular education classes. Based on 125 undergraduate programs, Viali (2008) concluded that quantity and quality of the statistics disciplines offered to future mathematics teachers must to be improved. In special, it is important to give support to their job of teaching statistical contents. In another view, in the same direction, Pamplona (2009, 2010) made a qualitative analysis of teaching practices at universities based on the opinion of five experienced instructors, concluding for the need to integrate the statistics disciplines with the objectives of a teacher preparation program.

At the Institute of Mathematics and Statistics of the University of Sao Paulo, Brazil (IME-USP), Mathematics Education students are required to complete two introductory statistics courses. The syllabus of the first one (referred from now on as STAT 1) includes combinatorics, descriptive statistics, probability and discrete random variables. The text books usually recommended are Magalhães & Lima (2013) and Bussab & Morettin (2013). Besides the discussion of teaching-learning aspects, the course objectives are to provide statistical literacy and statistical reasoning, as defined in delMas (2002). Also, Garfield & Ben-Zvi (2008) presented a comprehensive review of research studies in disciplines that contain statistics at college level. They mention the importance to support future mathematics teachers in their job of teaching statistics.

In this paper we present two of the activities used during 2013 (morning period) of STAT 1. We also comment on the course overall results, including a post test.

2. Activities

The activities presented are two projects developed by the students that involved data analysis and a didactic activity preparation. In the first activity, named Project 1, students organized themselves in groups, and chose a theme they wanted to investigate based on an available data set. In the other activity, named Project 2, students also worked in groups to prepare a practical activity, with relevant supporting material, to

be used in middle or high-school classes. In the sequence we briefly discussed the projects. A comprehensive discussion of the course activities, and their teaching-learning bases on Vygotsky´s Social-Historical Theory (Vygotsky, 1934/1987) were discussed in Magalhães & Magalhães (2014).

2.1 Project 1: Data analysis

This activity was organized with real data, which is an important recommendation for introductory statistics courses. The project aimed to use statistical tools in real contexts, in which students could relate theory to practice, in a context for group collaboration. The task included a written report, an oral presentation, and a class discussion.

The data set to be worked on was provided to students, it had been collected in 2012 and 2013 classes, through a questionnaire, since sampling and estimation were not subjects of STAT 1. The questionnaire included biometric data such as weight and height, and personal information such as gender, age, home region and school background. Other variables were time spent on studying, transit, and internet. There were questions on statistics prior knowledge and on reasons for pursuing a mathematics teaching career. Answering the questionnaire was voluntary and resulted in a total of 212 observations with 49 of them from the STAT 1 class.

The students organized their groups with three up to six participants, and they chose the theme to study through the given data set. They were free to use any software available and to complement their information using newspapers, internet and scientific journals. The project took three weeks and at that moment in the course the only statistical tools available were tables and graphs.

As discussed in Magalhães & Magalhães (2014, p. 36), Project 1 produced interesting results that might provide future teachers with a bases to create a learning and development environment in classrooms. In their words:

> *This project created contexts for collaborative work at several points: the group choice of the theme, the report writing, the oral presentation and the class discussion. They all involved ways to think and act that, due to the diverse experiences of the participants, might have created cognitive and affective conflicts central to development. We would say that the activity created possibilities for collective learning, potential for the participants to move from what they know and can do by themselves to what they can develop as a group. In other words, it created ZPDs (Zone of Proximal Development) to transform participants' agency. Group participants had to learn how to listen to others and to be responsive to the actions of others, as well as to be responsible for their own actions.*
>
> *In general, students' participation was good in all the steps of the activity. They had the opportunity to apply statistics to real data and an initial lesson in statistical reasoning. They had to evaluate arguments and opinions, and establish limits to their conclusions. A suggestion for a future offering of the course would be for groups to revisit their projects to incorporate statistical ideas discussed later on in the course.*

2.2 Project 2: Didactic activity preparation

In this project, students in groups, created or adapted a practical activity to produce an *active learning activity*, as discussed by Socio-Historical researchers. The objective was to create context so that students could, through practical activities, relate the concepts learned in the course to the ones they would be expected to teach in middle and high-school classes. The task took four weeks including a report writing and a poster presentation.

According Magalhães & Magalhães (2014, p.37), the activity provided context for teaching-learning of statistics concepts throughout its conduction. That is, it created critical collaborative relationships to task production in small groups that included report writing and poster presentation. As pointed out by the authors:

Participation was intense during the poster presentation. The students visited the posters asking questions and taking part in the practical activities proposed. They discussed how well the activity would work in a Brazilian school class. It was obvious that the groups were quite proud of their work and for several students it was their first experience of thinking as a teacher.

Project 2 created a context for the externalization of the statistical concepts internalized through classroom practices, by carrying out an activity in which students had to work with colleagues to collectively create or adapt a practical activity to produce an active learning activity. The proposed task also focused on creating contexts for learning and development through students' collaboration.

Project 2 requires participants to evaluate the mastery of their own mental processes concerning the scientific concept chosen, in order to develop their exercise, organize their poster and to discuss their work with colleagues during poster visiting. As Vygotsky (1934/1987) suggests when discussing the process of scientific concept development, this process is central to concept formation. It takes place in collaborative work provided by classroom instruction in which, as stressed by Garfield and Ben-Zvi (2008), learning and development occurs, when ZPDs are created as collective ways of working together.

3. Quantitative results

In this section we present results on STAT 1, 2013 morning period. The activities impact the whole course and we will make some comparisons with previous editions of the course. We also comment on the outcomes of a questionnaire and a post test.

Table 1 presents some figures related to the whole course in three years, 2011 to 2013 (STAT 1). In those years, we are assuming that we have the same level of difficulty in the assessments and approximately the same criteria to attribute grades. The results indicate small changes from year to year. The dropout rate is relatively high, and the pass rate is moderate even after the exclusion of the students that dropped the course. Related to final grade means, it is worth to mention that these numbers are typical in mathematical courses at University of Sao Paulo.

Table 1: Comparative results on different editions of the Statistics course

Year	Enrolled	Dropout Rate	Pass Rate*	Final grade mean (sd) all students	Final grade mean (sd) passing students
2011	67	28%	77%	5.3 (1.4)	5.9 (0.8)
2012	66	32%	56%	4.6 (1.5)	5.6 (0.8)
2013	75	28%	65%	5.0 (1.6)	5.9 (1.0)

(*) The percentage was computed excluding the students that dropped the course.

In March 2014, eight months after finishing the STAT 1 course, we asked the students who had succeeded to answer a questionnaire and to complete a multiple choice test. Participation was voluntary and anonymous, and we got 22 responses.

The questionnaire asked students´ opinion about the projects contribution to Statistics concept learning and use. With respect to Project 1, two items were of interest: understanding of variability and the students´ perception of the usefulness of statistics. Notice that variability is a central concept in statistics. As to students´ education, it was important the relationships between the school content and students` real life experiences. Figure 1 presents the percentages results of Project 1 with respect to these items. The majority of the students recognized the project positive contribution to both issues.

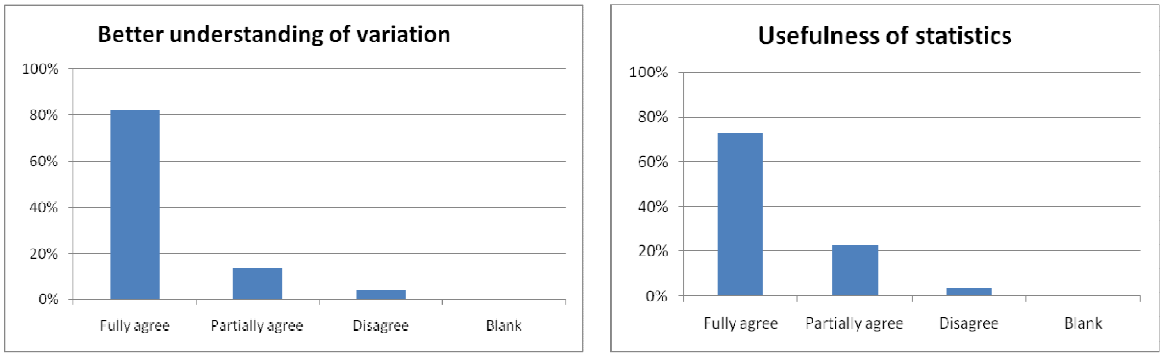


Figure 1: Project 1 contributions

To evaluate Project 2 contributions, we asked questions about the project role on statistical concepts learning and on motivation to teach statistics in a future job. The percentage rates are presented in Figures 3. Again, the students´ opinion indicated positive results but not as intense as the ones observed in Project 1.

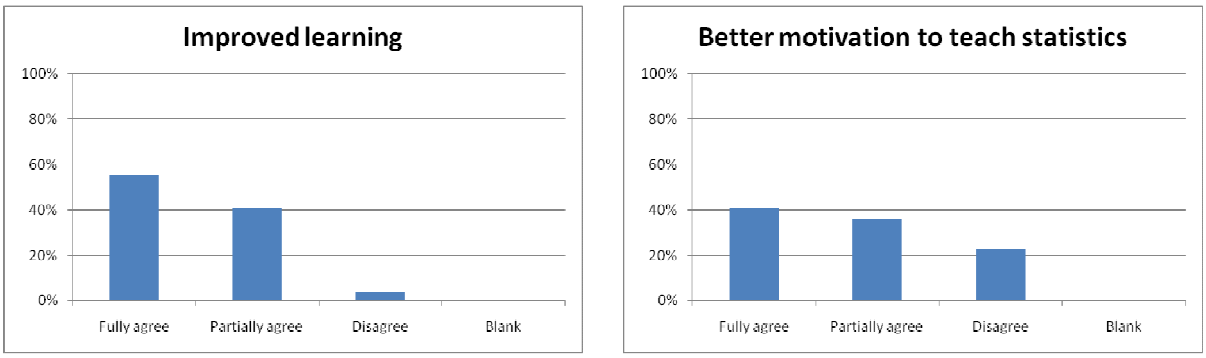


Figure 2: Project 2 contributions

Next, we discuss the results of the test which had 14 items referred to STAT 1 course. Table 2 presents some descriptive measures of correct answers proportion of the 22 students who completed the test. The values range from 0.43 to 0.79 with a mean of 0.61 and standard deviation of 0.10. Average value slightly exceeds the average final score shown earlier on Table 1 (0.59, using a scale 0 to 1).

Table 2: Summary measures of the proportion of right answers

N	Mean	Sd	Min	Q_1	Median	Q_3	Max
22	0,61	0,10	0,43	0,55	0,64	0,66	0.79

The same test was answered in 2010, and in 2011, for students which were completing the Education Math degree at IME-USP in these years. They formed a group of 38 students (named *Other years*). It is estimated that 50% of this group have also attended additional elective courses in the area of statistics. At the moment they did the test, they may be better prepared in statistics than the STAT 1 students. Note that the attendance to both tests does not come from a random sample or a population census, so conclusions are limited to the group tested.

We present in Figure 3, the proportion of the correct answers by items in the two groups, STAT 1 and *Other years* students. The STAT 1 students had better performance in 7 items and there was a tie in one item.

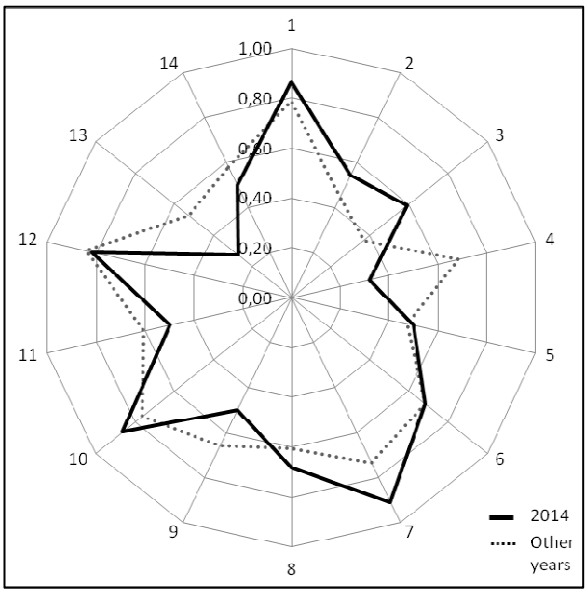


Figure 3: Proportion of correct answers by items

The two items with the lowest result for STAT 1 students, 4 and 13, were also the ones with greater difference between STAT 1 and *Other years* students. These items involved distribution concepts including measures and graphs interpretations (see the statements in Figure 4).

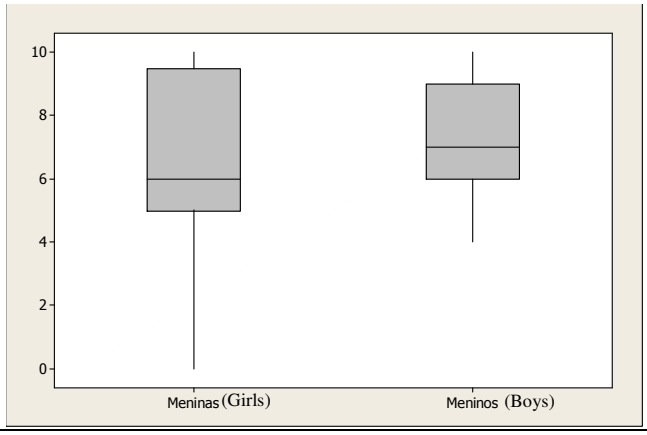
4. Suppose wages average in São Paulo is higher than in Rio de Janeiro. Random choosing an employee in each city, is the one from Sao Paulo more likely to have higher salary?	Yes ( ) No ( )
13. The diagram below indicates students´ grades (0 to 10) of a test. Does the limit for 25% better girls´ grades overcome more than 75% of the boys´ grades? 	Yes ( ) No ( )

Figure 4: Items with the lowest scores

4. Final Comments

This article discussed two activities for STAT 1 class attended by Mathematics Education students, in IME-USP in 2013. These activities could be applied in introductory statistics courses anywhere, and particularly to future mathematics teachers. As we have already discussed, the activities brought qualitative advances to students´ learning and development. They also enhanced considerably students´ participation and involvement in class discussion which, in theory, resulted in better concept learning. Quantitative results were also presented, and compared with previous

courses, indicating similar performances.

Improving the quality of statistics courses for future mathematics teachers should be a goal of the national statistical community. In this direction, emphasizing concepts and their use, rather than formulas, can be an important step to allow mathematics teachers, effectively, contribute to statistical literacy development among their middle and high school students.

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