Radical Statistics: Teachers and Students on the Highwire

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Abstract

Radical Statistics is a hands-on project promoted by the Portuguese Statistical Society (SPE) geared towards high school students and teachers. It aims to advance statistics through various activities which students can relate to, emphasizing the importance of dealing with real data in the learning process as well as raising awareness of the importance of statistics in daily life. Over 350 students and teachers from different regions of Portugal participated in all three phases of the two editions of Radical Statistics, namely the Online Competition, the Adventure Camp and the Teachers Training Session. Several statistics-based activities for each of the different phases of the project and how they can be incorporated in a Mathematics curricular program will be shown. By presenting Radical Statistics as an activity for both students and teachers, we hope to attain an excellent symbiosis between theoretical concepts and how they can be applied in real life situations. This is accomplished by dealing and working with real data sets in conjunction with smaller activities that entice students to reflect upon the wide range of concepts involved.

Key Words: real data, statistics education, students, teaching practices.

1. Introduction

A series of curriculum reforms in Mathematics in Portugal have led to the introduction of an increasing number of subjects related to statistics into these curricula, ranging from general concepts to simple linear regression [3,5]. Radical Statistics is a hands-on project directed at both high school students and teachers with its main objective being to introduce statistics via a series of activities which students can relate to, thus heightening their awareness of the importance of statistics in their daily life (Figure 1).

Figure 1: Radical Statistics for students and teachers.

Some of the activities, such as “Black Eyed Peas”, have the main goal of introducing concepts such as “Population versus Sample”, while others are designed with real data collected and analyzed by the students. In the 1st Edition (2012), over 60 students and teachers from different regions of Portugal participated in all three phases of Radical Statistics, namely the Online Competition, the Adventure Camp and the Teachers Training Session. At the present time, 280 students are participating in the online competition of the 2nd Edition of Radical Statistics. All the activities are meant to be complementary to each school year's curriculum and are planned in such a way that they can be easily incorporated into a class. With this project, we hope to expand, promote and reinforce the need for Statistics in Portugal and its importance in each person's daily life.

2. The Online Competition

From the beginning of the year till early May [4], several teams of high school students from grades 10 and 11 in Portugal participate in an online competition. As they start the completion, the team enters a *Parallel Universe*, and in order to exit from it they will need to successfully complete a series of challenges and gather a set of clues all the way to the Castle (8th level) at the top of the mountain where you they will face a final test. The teams need to overcome the challenges proposed in 8 different scenarios, namely the Camp, the Mountain Trail, the Waterfall, the Cliff, the Suspension Bridge, the Forest, the Mine and the Castle. Throughout these eight levels of increasing difficulty, students are tested on the different statistical subjects covered in curriculum courses of mathematics [1, 2].

From level 1 through 4 the students will be tested on general concepts such as types of variables, population and sampling methods, measures of central tendency and dispersion, frequency tables and graphical representations (Figure 2). Notice in Figure 2 that, in each level, the team can choose a different character, called an AVATAR profile (blue icon), to play the game.

Figure 2: Levels 1 through 4 in the online competition (the Camp, the Mountain Trail, the Waterfall and the Cliff).

In each scenario the team has the possibility to find one "tip" and one "curiosity" that can help them in answering the 3 sets of questions that they look for in the scenario and answer. After completing them, they can move on to the next level. By accumulating tips and curiosities from the different scenarios, they have the chance to exchange them by a new trial of a level of their choice, and improve their scores. In each set of questions, they have 3 chances to answer them correctly. The rank of a team in the competition is determined by the scores obtained at each level and the time of execution.

In the last 4 levels, Figure 3, the subjects covered include outliers, association, correlation and linear regression, with teams having extra time in the final levels in order to answer more complex and elaborated questions.

Figure 3: Levels 5 through 8 in the online competition (the Suspension Bridge, the Forest, the Mine and the Castle).

The winning teams, 15 in total, will have one further challenge - to participate in an Adventure Camp, held mid-May.

3. The Adventure Camp

Over the course of one full weekend, students and teachers participated in various activities in which they had to solve statistical challenges. The activities comprised a variety of different sports such as slide, high ropes, and old mine, already existing in the Adventure Camp, in which students had to solve statistical problems specially designed for every radical activity, in order to move on to the next challenge. As an example, in Figure 4 we witness the challenge that the teams had to go through in the old mine. This old mine, inactive for many years, was invaded by tropical mosquitoes, *Aedes vigilax*, the vector responsible for several dangerous diseases. To exterminate the mosquito and thus protect the inhabitants of the nearby villages, it is necessary to determine the extent of this mosquito population that now lives in the mine. For this, a group of experienced investigators was invited to enter the mine and capture as many mosquitoes (table tennis balls) as possible. Because the mine is in danger of collapse,

the task has to be completed quickly, without the team stopping at any time. It is known that another brave team of researchers had previously visited the old mine and were able to mark 70 mosquitoes with a florescent ink (marked tennis table balls). Mosquitoes already observed by the previous team are marked. At the end, each team will have collected a certain number of mosquitos; some maybe marked and some may not. They will have to use this information to estimate the total number of *Aedes vigilax* mosquitoes.

Figure 4: Experiencing capture-recapture sampling in the old mine.

4. Teacher Training Session

The project also included a 25-hour training course for teachers entitled "Radical Statistics: a different way to teach statistics" whose main objective was to show teachers different ways to use their skills in order to improve and deepen their knowledge in statistics and present them with different strategies on how to solve statistical problems in their daily practice. All the activities presented in this course were planned using R [6], a free software which could then be used in their classrooms. Among many activities, the "Black Eyed Peas" is an example of one of these in which the main objective is to show that, in some cases, a good sample does a much better job at getting a truer picture of the population. The video "My Humps" is presented for 1:46 minutes, after which the students are asked "How many times did you hear the word 'humps'?". They immediately complain about the unfairness of the task, but they also realize the various inherent problems and the care needed when dealing with a population. This situation simulates some of the common problems which touch upon the following issues: the individual does not fully understand the task being studied; the individual answers anything they want when they do not know the real answer; or finally the possibility of making several mistakes in data registry when dealing with large data sets. These problems will produce undesirable variability and will be clearly seen in the data collected from the students' answers. This experience continues, now in a more controlled environment, where the students need to count the letter 'u' from a text of the song presented to them. After 30 seconds we registered their answer and compare the two data sets. The students can easily produce a parallel histogram of the two datasets in R (Figure 5), and clearly see the different behavior, where the latter shows much smaller variability. The moral of the story is that Population Studies require special attention and careful execution.

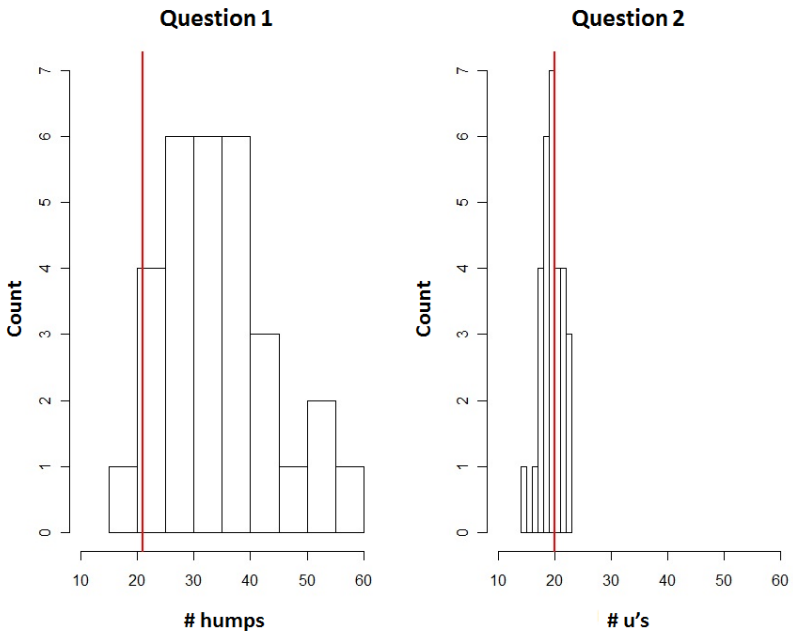

Figure 5: Population *versus* Sample activity.

5. Final Comments

By presenting *Radical Statistics* as an activity for both students and teachers, we hope to attain an excellent symbiosis between theoretical concepts and how they can be applied in real life situations. This is accomplished by dealing and working with real data sets in conjunction with smaller activities that entice students to reflect upon the wide range of concepts involved. Working with real data sets will give students a deeper awareness of how important it is to know more about the population in which they live, how studies can be made, and the impact and relevance of statistics in their everyday life.

Teaching statistics in high schools can be a challenge for teachers. Teachers need to use methods that will capture students' attention in a technological environment constantly changing in unpredictable ways. Given that statistics now increasingly included as part of the mathematics curricula in areas such as general science, social sciences and other technological fields, there is a pressing need to modify teachers' attitudes towards statistics. Convincing teachers that statistics can be the field of mathematics that can actually engage and motivate students to study mathematics will win teachers attitudes over towards statistics and will minimize teachers' temptation to consistently leave statistics topics until the end of the school year to be taught, where very little can be said about the subject. By offering and involving teachers in *Radical Statistics*, we will show how to reduce teachers' resistance to teaching statistics, add to their teaching skills through available teaching activities, and at the same time get teachers and students to speak the same language.

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