A TEACHING EXPERIMENT DEALING WITH STATISTICS IN HIGH SCHOOL

Sandra Magina[1], Irene Cazorla[2] and Edgard Silva[3]
[1]Pontifical Catholic University of São Paulo, Brazil
[2]State University of de Santa Cruz, Brazil
[3]Pontifical Catholic University of São Paulo, Brazil

This study involves a teaching experiment to improve students' understanding of statistics basic concepts, by integrating statistics and data analysis related to science and social studies, contextualized in Vitruvian Man of Leonardo da Vinci. The design followed the model proposed by Rumsey (2002) for the statistical competence. Twenty two 10th grade students from a public school in Sao Paulo, Brazil went through all phases, from the formulation of the hypothesis, the collection of their own data, the discovery, the use of tools to interpret the data (in both paper and pencil and computer based), and to the communication of the result. Participants were given a pre and a post-test. The results are discussed in terms of the nature of teaching strategies and innovative use of technology. Students showed an expressive improvement to deal with statistical concepts from pre to post-test.

INTRODUCTION

The implementation of the statistical concepts in the high school in Brazil (National Curricular Parameters–PCN, Brazil, 1998 and 2002) is under the teachers' responsibility of Mathematics. Analyzing the curricular syllabuses of Mathematics, the existence of a subject of Probabilities is observed, aimed to the formal aspect of the theory of Probabilities, focused on the University education. On the other hand, in spite of PCN giving some teaching orientations from a perspective of the methodology of projects, emphasizing the collection of data by own students, Silva (2007) verified that the "statistical projects" implemented at the schools are summarized to the mere rising of data. Besides, those risings are simply diagnosis or descriptive, linked to the daily. Actually, there very rarely is any explanatory of the scientific perspective research, linked to the scientific phenomena.

Thus, the present study investigated the potentialities and limitations of teaching experiment to improve students' understanding of statistics basic concepts, by integrating statistics and data analysis related to science and social studies, in both paper and pencil and computer based.

STATISTICAL LITERACY AND STATISTICAL COMPETENCE

Rumsey (2002) emphasizes the importance of Statistics in both literacy in statistical citizenship and statistical competence. This last one refers to the underlying basic knowledge to the thought and statistical reasoning. The author proposes a model for introductory subjects of Statistics, in the graduation courses, that is, in the university education. Thus, the first objective of those subjects should be to assure the statistical citizens' major, that understand and be capable to consume information which permeates their daily lives, thinking critically on that and making decisions using that information; the second objective should be to develop the research scientist skills "We must be sure to promote the use of the scientific method in all of our students: the ability to identify questions, collect evidence (data), discover and apply tools to interpret the data, and communicate and exchange results" (p. 1).

Although our study aims the High School, we opted for the Rumsey (2002) model that moves forward in the concept of statistical learning when proposing a model to promote the investigative spirit, which is a natural scientific thought. It is important to note that although some Brazilian schools are trying to implement interdisciplinary projects, in most of them the Mathematics teacher is the last to be invited, and when s/he is so, her/his participation is just to deal with the data, in general qualitative data, which don't move forward in the formation of the scientific spirit (Silva, 2007).

For Rumsey (2002), statistical competence involves five components: attention to the data, basic understanding of Statistics, collect data and results, interpretation in a basic level and basic communication skills, presented in Picture 1 of the methodology. Our proposal of the teaching experiment followed this model.

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php [© 2010 ISI/IASE]

METHODOLOGY

The 22 students participated in the teaching experiment, which carried out through three phases: visit to Leonardo da Vinci exhibition; collect students' data (measurement of the height and of the span of the students' arms, among others) and data processing environment in the paper and pencil, and classes in computing environment. Participants were given a pre and a post-test, containing six questions and 27 items related to reading, interpretation and construction of graphs and tables, as well as, calculation and analysis of measures of central tendency and dispersion. Our hypothesis is that to visit, for the first time in their life, the da Vinci exhibition will be an important motivator factor for these students mainly because they will be able to prove, or not, by themselves, the measures of Vitruvian Man.

To collect the data students used a tape measure and scales, and in the computer lab the software Tabletop (1994) with an itinerary of activities. Tabletop is a software meant to deal with elementary statistical data, that has two interfaces: one that is the one of the database on table form and, the other, a graphic representation (Venn diagram, uni-variable and bi-variable analysis), all represented by iconical resources.

Before presenting the teaching experiment it is essential to point out that the only statistics class theses students were having was throughout this project. In other words, the students were not learning statistics in the classroom at the same time they were doing the project.

Teaching Experiment

The teaching experiment followed the model for the statistical competence proposed by Rumsey (2002), synthesized in Figure 1.

Requirement	Model proposed by Rumsey (2002)	Model of teaching experiment
Attention to the data	Promotes motivation to the students, because the data are present in the daily life and decisions can make impact in our life.	The students visited to the exhibition "Leonardo Da Vinci - the exhibition of a Genius", focusing on the "Vitruvian Man".
Basic understanding of Statistics	Is the capacity to relate the concept inside of a non-statistical theme; to explain what the concept means, to use it inside of a problem and to answer subjects on him. To understand the concept instead of making calculations.	The students worked the relationships among the several measures of the human body using statistics elementary concepts, relating their characteristics and properties.
It collected data and results	To give the opportunity to the student to collect their own data and to find the basic statistical results, so that the student participates in his own learning.	The students collected their measures: weigh, height, span of the arms, number of bothers and sisters, age, gender.
Interpretation in a basic level	To know how to interpret statistical results (measures, graphs, tables etc.) with their own words.	The students built and interpreted the results, in both classroom (paper and pencil) and computer lab (Tabletop).
Basic skills of communication	Reading, writing, demonstration of the statistical information. Transmit to another person the statistical information.	The students elaborated written reports to communicate to their conclusions to pairs.

Source: Adapted from Silva (2007, p.27)

Figure 1. Model for the statistical competence proposed in the teaching experiment

The students went through all phases of the scientific research, from the formulation of the hypothesis, followed by the collection of their own data, the discovery and use of tools to interpret the data, using pencil and paper (classroom), and Tabletop software (computing environment), to the exchange communication of the results.

The hypothesis of motivating research of the teaching experiment was "the span of the arms is the same to the people's height", inspired in the Vitruvian Man (Figure 2), contextualized by the visit to the exhibition (first moment).

In a second moment, at school, the students collected their own data in classroom. To do that they weighed and measured the span of their arms and their heights (Figure 2), being their data written down in a table in paper previously distributed in the blackboard. Besides that, student's name, age and number of brothers and sisters was written down. Below the measures of central tendency and dispersion were worked, building tables and graphs using pencil and paper.

Figure 2. Leonardo da Vinci´s Vitruvian Man and the students' measures

In the third moment, the students went to the computer lab, where they inserted the data on the software Tabletop, following an itinerary previously described, which consisted of activity records to be answered by them, in pairs.

Teaching Strategies

The teaching strategy had as an important hypothesis that the span of the arms is the same to the people's height, inspired in the Vitruvian Man, contextualized in the visit to the exhibition on Leonardo da Vinci. That visit, very unusual in Brazil, impressed the students, just as we can appreciate in their comments: "Didn't know that da Vinci had done so many things!", "How did he know that the span of the arms is the same to our size?", "Did he open the bodies to know how they worked?!", "How, in that time, could he already know how the helicopters would be like?" among others, which showed us how the students began to arouse their investigative spirit.

During the collection and registration of the data, it was debated the meaning of each measure in terms of variables and their nature, and elicited the students to notice the difference among the variables: gender (qualitative nominal), age (discreet, if counted in number of years), number of children (discreet), weigh, height and span (continuous). Did we also ask how we could summarize the data? How to characterize the groups? How to communicate the data? What the profile of men and women? Who are taller, heavier? Are the students in the ideal weight? What is the Body Mass Index (we asked the students to investigate what is BMI and which are the reference limits).

Students were invited to think of research questions, such as: is it true that there is a relationship between the height and the span of the arms, as da Vinci would say? If yes, does it depend on the weight? What does happen if we divide the height for the span of the arms? What does that mean? Does this relationship depend on the student's gender? Does it depend on the student's age? How to demonstrate the validity of the hypothesis? What statistical measures can be used? What graphs?

EDUCATIONAL REFLECTIONS ABOUT THIS TEACHING EXPERIMENT

We realized that in spite of having only 22 students, the amount of data was too big to just be work with paper and pencil, even so students calculated the main measures, and built tables and graphs, but this task became tiresome and painful. When the students got to use Tabletop to make calculations, to count and to create graphs, they were fascinated. Thus, students built a series of graphs, tables, calculated measures, but two graphs marked our teaching experiment: the diagram dispersion of the span of the arms in relation to the height (Figure 3) and the distribution of the number of the students' of the class siblings (Figure 4).

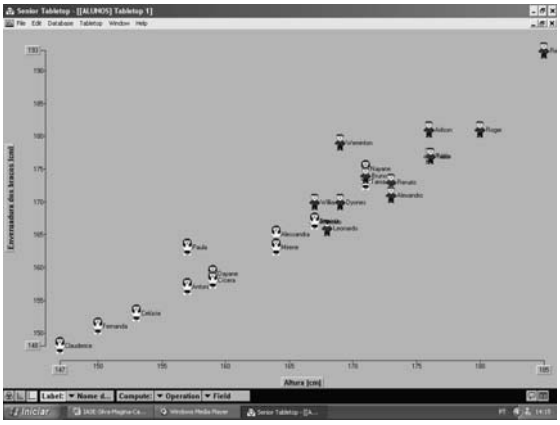

Figure 2. Relationship among the span of the arms and student's height

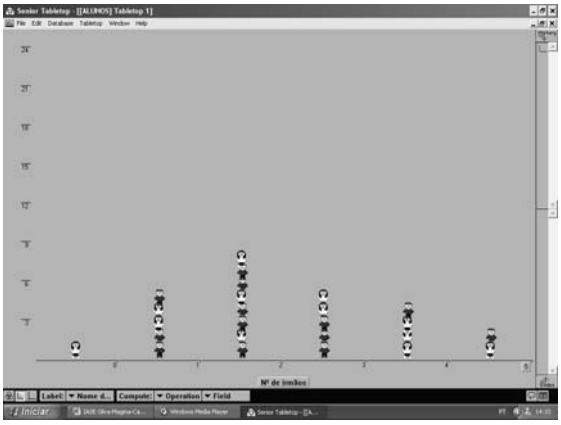

Figure 3. Distribution of the number of brother and sisters

By dealing with TableTop, students were able to identify each other, who appeared in the screen by represented in points of the Cartesian plan, of iconical form, with their names. Thus, they began to make connections with the content of functions, observing that there can be more than a student with the same height, however with different spans of the arms, which is not allowed in a mathematical function. Moments like this were mainly fruitful to take advantage to explain the variability concepts and variation (Silva, 2007), inherent to the biometrics measures.

From that perspective the students were asked if with those empiric evidences, could accept or refute Vitruvian Man hypothesis, that is, the span of the arms (Y) is the same height (X), mathematically presented by the linear function: Y = X. Most students agreed, but not all. It would be possible to continue to provoke students proposing some more questions, but students would not be able to answer them, since they would need to use other statistical concepts, which are not studied at this level in Brazil.

However, comparing the students' performances from pre to post-test (M = 2.74, SD = 0.90 and M = 5.23, SD = 2.0 respectively) it is possible to confirm the contribution of this teaching experiment concerns the statistical basic concepts such as mean, mode, median, range as well as graph and table interpretations. This difference was significant ($t(21) = -7.168$, $p < .001$).

FINAL CONSIDERATIONS

Our study made us believe in the possibility of teaching Statistics, in the scientific way and using data from students interesting. We confirmed that motivation is essential to create an environment that allows students to acquire the basic ideas of Statistics. We also realized how many different projects could be carried out, exploring statistical ideas as well as the relation between mathematical and statistical concepts.

We have no doubt that working in computer based was, on the one hand, one of this motivation, since it was easy for students exploring data through many different graphs, which were built quickly. But on the other hand it brought other challenges, since most of the students didn't have familiarity with the computer. This made us review the planning.

REFERENCES

Brasil (1998). Ministério da Educação e Cultura. Secretaria de Educação Fundamental. *Parâmetros Curriculares Nacionais: Matemática*. Brasília: MEC/SEF.

Brasil (2002). Ministério da Educação e Cultura. Secretaria de Educação Média e Tecnologia. *Parâmetros curriculares nacionais (Ensino Médio): Parte III–Ciências da Natureza, Matemática e suas Tecnologias*. Brasília: MEC/SEB.

Rumsey, D. J. (2002). Statistical Literacy as a goal for Introductory Statistics Courses. *Journal of Statistics Education, 10*(3), 1-12.

Silva, C. B. (2007). *Pensamento estatístico e raciocínio sobre variação: um estudo com professores de Matemática.* Doctoral Thesis. Pontifícia Universidade Católica de São Paulo, São Paulo. Available from http://www.pucsp.br/pos/edmat.

Tabletop (1994). *New computers tools for logic, information, graphing and data analysis*. Hands on!, *17*(2).