

Statistical Training of Pre-Service Teachers with Application in School Practice

Miriam Cardoso Utsumi¹, Irene M. Cazorla² and Verônica Yumi Kataoka³

Abstract

This paper discusses the way that actions developed under a programme (PIBID – Scholarship Program for Pre-service Teacher) from the Brazilian government can contribute to the learning of teaching, by considering four pre-service mathematics teachers (undergraduate students), from the university in São Paulo, who participated in a training activity using Didactical Sequences (DS) of Statistics, and then applied these to students in their 6th to 9th years of schooling. In general, the experiment in school was evaluated positively, due to the active participation of the students – capable students took responsibility for helping the weak students, lazy students were stimulated to work – and because most students were able to make sense of the tables and graphs, and learned to compute the mean, the median, mode for much grouped data. It is considered that programme has provided training times to pre-service mathematics teachers, who learn the necessary concepts for teaching, as well as how to prepare and execute activities in the classroom with the guidance and under the supervision of professors and teachers. Therefore, those activities provide security for pre-service teachers in their teacher training.

Keywords: pre-service teachers; teaching of statistics; middle school; didactical sequences

1. Introduction

In Brazil, teachers are expected to have an understanding of probability and statistics, as suggested by the National Curricular Parameters for correct teaching, as suggested by National Curricular Parameters for correct teaching.

¹ Miriam Utsumi. Rua Hélio Polezer Jr, 824, Pq. da Represa, Paulínia, SP, Brasil. CEP 13144-600. Fone: (55) 19 3884-1118, Profa. Miriam Utsumi. SMA- ICMC/USP. Av. Trabalhador Sancarlense, 400, CP 668, São Carlos, SP, Brasil. CEP 13566-970, Assistant Professor, Institute of Mathematics and Computer Science, University of Sao Paulo. Email: mutsumi@icmc.usp.br.

² Assistant Professor, Santa Cruz University. Email: icazorla@uol.com.br

³ Assistant Professor, Santa Cruz University. Email: veronicayumi@terra.com.br

Those concepts are in section known as “Treatment of Information” (data handling) in elementary schools (Brasil, 1997) and middle schools (Brasil, 1998), and in the “Data Analysis” section for the high school (Brasil, 2002, 2006). However, results for the last National Examination of Performance to Students from Mathematics Courses show that the performance of pre-service teachers (undergraduate students) is much lower than expected, with the further problem that these graduates are legally authorised to work with students in elementary and high schools without having sufficient knowledge, especially relating to the didactical aspects, to provide a quality education.

With the aim of reversing this situation, in 2007 the Brazilian government created the Scholarship Program for Pre-service Teachers (PIBID) in order to support and enhance the learning of teaching by pre-service teachers, by placing them in schools, with responsibility for preparing and implementing activities in partnership with adviser professors at the university and supervisor teachers at school.

Several researchers have reported experiences with pre-service teacher training and studies have been developed about these experiences. For instance, Groth and Bergner (2004) reported on teaching statistical sample, Canada (2006) about variation in a probability context, and Leavy (2010) about informal inferential reasoning.

In this paper we present a discussion about an application of probability and statistics activities by a group of four pre-service teachers in mathematics, all participants in PIBID with students from the 6th to 9th years of schooling (from 11 to 14 years old) at two public schools in the State of São Paulo.

2. Literature Review

As in other countries, statistics and probability are part of the mathematics curriculum in Brazilian schools. According to Batanero, Godino and Roa (2004) this is due to the usefulness of statistics and probability in daily life, its instrumental role in other disciplines, the need for basic stochastic knowledge in many professions and its role in developing critical reasoning.

Despite this, Shaughnessy (1992) points out that the unfamiliarity of mathematics teachers during their training with statistics is a major obstacle to successful teaching and school learning of this subject.

Indeed, Nicholson, Road and Darnton (2003), Pecky and Gould (2005); Cazorla (2006); Contreras, Batanero, Diaz and Fernandez (2011) all argue that teachers from mathematics graduate courses, sometimes have some basic training in probability and statistics, but generally are not trained in issues related to teaching these subjects. According Viali (2008), most of major mathematics courses in Brazil offer only a single 60 - 75 hour course on descriptive statistics and probability, and this rarely deals with aspects of teaching statistics. For example, in the "Introduction to the Theory of Probability" course, the goals involve familiarising the student with probabilistic reasoning and providing a basic knowledge for the proper understanding of statistical methods.

In this study, the statistics course provided is the Theory of Probability at a higher education level without discuss about didactical aspects of statistical thinking. This way, it will be difficult for prospective teachers to teach in basic education as shown below. An analysis of the contents of the course (frequency and probability, conditional probability and independence, random variables, discrete distributions (Uniform, Bernoulli, Binomial, Geometric, Hypergeometric and Poisson), continuous distributions (Uniform, Exponential, Gamma, Normal and t-Student), Normal approximation to the Binomial, n-dimensional variables, hope, variance, covariance, Markov inequality and Central Limit Theorem) - suggests that there are many topics covered, but the topics refer only to probability and statistics at an advanced level, and therefore do not take account of the level of content that these teachers will have to teach in middle school, much less how to teach such content.

Franklin and Kader (2010) propose that the knowledge required by math teachers who teaching statistics must be based upon three principles: knowledge of what we would expect educated members of society to know; that the knowledge used for teaching statistics is not the same as the statistical knowledge needed for other statistics-based professions; and, the statistical knowledge needed for teaching must be usable for such challenges as interpreting a student's error, using multiple forms to represent a statistical idea, and developing alternative explanations.

Thus the Brazilian teachers who teach statistics need to understand the basic concepts of statistics. They should gain “both technical and conceptual knowledge” of the statistics and probability content that appears in the curriculum for their students, which is described in Brazil (1998) and is summarised in Table 1.

Table 1: Statistic and Probability Content in the Curriculum for Brazilian Schools

Content	6th – 7th Grade	8th- 9th Grade
Table and Graphs	To read and understand data in tables and graphs To collect, organize and describe data in tables and graphs	To build pie charts, column charts, histograms and frequency polygons. Absolute and relative frequency samples, population
Central Tendency Measures Sample Space, Probability	To understand mean as a tendency indicator Synthesize, communicate, and draw conclusions Sample Space and estimation by ratio	To Calculate and understand mean, mode, median To present the data globally, highlighting relevant aspects, to allow inferences Multiplicative principle Design of experiments and simulations to estimate probabilities and check provided probabilities.

In this context, we have, in our study, similar goals to Peck and Gould (2005, p.1): the development of an experience for pre-service teachers that would provide them with the necessary background to teach introductory statistics; the provision of help for teachers to incorporate real data, active learning and technology in teaching introductory statistics; to provide access to a variety of resources for teaching statistics; to create a community of learners who can advise and support each other in matters of classroom practices, pedagogy and understanding statistical concepts.

To achieve these goals, we trained pre-service teachers in applying two Didactical Sequences (DS): "Profile of the Class" and "Water Planet" (Cazorla and Santana, 2010).

The concepts involved in these DS are suggested in “Treatment of Information” (data handling) Section (Brazil, 1998). These DS were designed for statistics teachers and are available in the Virtual Environment to Support Statistics Literacy Basic Education: AVALE-EB (Figure 1).



Figure 1: AVALE-EB's Homepage
 (<http://www.iat.educacao.ba.gov.br/avaleeb>)

In these DS students follow the steps of a cycle of scientific investigation: background of the problem situation, formulation of hypotheses; defining the variables; collecting and recording the data, calculation of statistical measures and constructing tables and graphs; data interpretation and communicating the results.

These DS use interdisciplinary content, contextualised within the school environment, exploring the cognitive aspects of learning and those related to the development of critical awareness of the use of natural resources and a respect for diversity. In DS students actively participate in all activities, so DS can contribute to statistical literacy by using statistical and probabilistic concepts that enable the development of the critical reading ability of basic education students, and can also contribute to the scientific education of these students.

3. Methodology

Initially, the four pre-service teachers were invited to participate in a training activity on two Didactical Sequences (DS) that would work with students in middle schools.

Following the training activity the four pre-service teachers made a plan to implement each DS at school for two hours per week for a month, using three weeks to work in a "pencil and paper environment" and one week to work in a "computing environment" followed by the application of a small statistical test. These activities were developed with students from five classes of 6th and 7th grade, and three classes of 8th and 9th grade students, totalling 16 classes in middle school.

4. Key Results

Throughout their training we found that despite the pre-service teachers having already attended an introductory course in statistics, they didn't know how to identify the nature of variables, which is an important competency to work with in the DS "Profile of the Class", in which students are encouraged to formulate research questions and helped to identify the treatment of nominal or ordinal qualitative variables and discrete or continuous quantitative variables and shown how to represent their data. They also revealed a feeling of insecurity, due not so much to lack of preparation in statistics, but more especially to a lack of preparation for the teaching of statistics. As a result the pre-service teachers studied each step of the sequences, and did additional reading to remedy their concerns and develop complementary activities before implementing DS with the students,, especially in the interpretation of graphs for middle school students, as this is the most commonly required activity in Brazilian educational assessments.

In the first application of the DS "Profile Class" with the classes of 7th grade, students were very excited and formulated several questions about aspects of everyday life, regarding for instance, favourite soccer team, number of pets, favourite food, taste in vegetables and salads, favourite sports, and favourite teacher. The DS gave students the opportunity to learn statistics while working with their own data and the contents explored could include: charts: bar, pie and dotplot graphs, measures of central tendency (mean, median and mode), and measures of dispersion (total amplitude).

In the “pencil and paper environment”, the activities were as planned: students were asked to construct statistical tables or graphs, they could see how to build up and to understand information from different kinds of sources. One of the pre-service teachers felt that there was a need to strengthen the interpretation of several kinds of chart in his two classes.

Before working with measures of central tendency with the students’ data, the pre-service teachers decided together that it would be interesting if such measures were intuitively perceived and they decided to use a game.

The game chosen was based on Super Trunfo® (Super Trumps) because it requires throughout that the player realizes that there are better cards than others in certain respects, and values that tie more easily than others. The original game has 32 cards and each card contains 6-8 pieces of information.

The pre-service teachers decided to create a version of Super Trunfo® themed movies with fewer cards (20), separated into four groups of five. The game produced was named “Super Movie”. It was important to reduce the number of cards and the amount of information from that in the original game so that study of the distribution of data was possible.

The pre-service teachers also studied the dynamics of watching games with students: how the cards were distributed according to three variables (release year, duration and revenue) and the best strategy for certain groups of cards (Figure 2). Throughout the game the students realized for example, that revenues worth more than \$ 1 billion had great chances of winning and that movies of more than 120 minutes duration were too long. The median, which is traditionally studied as an end in itself, had a practical utility in the game, because if in one of the variables, a piece of information was greater than the median, the possibility of gaining the card was over 50%. So the students had to compare variables, and calculate the mean, median and mode to beat their opponent. This game stressed statistical concepts.



Figure 2: Examples of Cards Designed By Pre-Service Teachers for the Game "Super Movie"

The pre-service teachers tried to use the "computing environment" with students, but there were problems, for example a slow internet connection when accessing the AVALE-EB made it impossible to work with the DS.

In the statistical test these students performed well. The pre-service teachers believe that their performance indicated that the questions were appropriate to the topics covered in this DS.

In the application of the DS "Water Planet", with students from the 8th and 9th grades, the concepts were studied only in the "pencil and paper environment." The contents that can be explored are: variables ordered by time; charts: bar, line and dotplot; measures of central tendency (mean, median and mode); and measures of dispersion (total amplitude, deviation, mean deviation, variance, standard deviation and coefficient of variation). It is also possible to relate the concept of per capita consumption of water with the arithmetic mean.

The pre-service teachers expected that using data from the student's own water bills (Figure 3) would motivate them to work with this DS. However this didn't happen, as most of the students didn't provide their own water bills, requiring pre-service teachers to work with data from the AVALE-EB database (Figure 4).

Movie”


		Data de Vencimento	FATURA Nº.										
		10/02/2010	2a. VIA										
Nome		Código do Consumidor	Data de Emissão										
Severino Silva		760.724-4	05/02/2010										
Endereço do Usuário		Nº Porta	Bairro										
Rua Castro Alves		934	CENTRO										
Endereço de Entrega		Nº Porta	Bairro										
Categoria-Economias		Localização	Mês de Referência										
BNP-001		01.001.0076.02.0934.00	01/2010										
Data de Leitura	Leitura atual	Leitura anterior	Consumo m³	Número do Hidrômetro									
03/02/2010	1.694	1.686	8	A95T027799									
Consumo dos últimos meses	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ	Medida dos últimos meses
	7	11	8	9	9	8	6	7	9	10	15	8	8,9

Figure 3: Example of a water bill in Brazil.

Nome	Jan	Feb	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
aida	115	103	142	177	131	115	82	114	126	119	126	128
amanda	196	178	187	185	156	159	153	168	163	161	186	186
brandao	220	180	230	260	24	235	268	245	250	238	256	228
cido	115	103	142	177	131	115	82	114	126	119	126	128
cris	288	314	311	414	357	370	399	350	350	367	326	338

Figure 4: Class database in AVALE-EB.

This activity demonstrated the difficulty students had in working with scales and the "simple rule of three." More time was thus spent making and interpreting graphs. The third week began with definitions of some measures of dispersion, amplitude, deviations and mean deviation. These measures were presented using graphs previously used by the students to help them understand their meaning. For example, students were asked to chart the average monthly water consumption of a family using a bar graph showing the consumption each month, and this showed that the deviations were nothing more than the distance from the top of the base to the mean line.

Students were given a table to fill with the data provided in the water bills and with which to calculate several measures of dispersion (Figure 5). With this table the students made calculations of the dispersion measures discussed and were able to make comparisons with their peers.

Month (i)	Consumption (x_i)	Mean* (\bar{x})	Deviation ($x_i - \bar{x}$)	Square Deviation ($x_i - \bar{x}$) ²
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Sum		-----		
Mean		-----		
*To repeat the mean in the all lines			↑ Mean Deviation	↑ Variance

Figure 5: Example of worksheet for the ST Planet Water

In the second school the pre-service teachers decided not to use AVALE-EB for the calculations, and instead made a simple table in Excel format, similar to that given to the students to fill in at the third stage. The table was completed automatically when students entered the water consumption for each month. The graphics were also constructed automatically when the table was completed.

The statistical test was very extensive and demonstrated that the concepts of median and average deviation weren't learned effectively in both schools.

5. Final Considerations

The pre-service teachers were limited in several ways: they were most focused on pedagogy over content. It considered that training activity as short workshop format is not conducive to the development of full content understanding. This is in according to Gattuso e Pannone (2002).

The difficulties experienced by the pre-service teachers can be explained, in part because the subject is not covered in their initial course for teachers of mathematics, and they are therefore untrained to present the contents of the Data Handling project and the didactic aspects that should be taught in basic education.

Their initial course for teachers of mathematics have only a list of concepts and procedures, but there is no evidence of statistics as a tool of quantitative scientific research, which allows the formulation of hypotheses, planning the collection, processing and analysis of data, nor as a language that permeates information conveyed by the media.

In general, the experiment in school was evaluated positively, due to the active participation of the students – capable students took responsibility for helping the weak students, lazy students were stimulated to work – and because most students were able to make sense of the tables and graphs, and learned to compute the mean, the median, mode for much grouped data with the help of Excel or AVALE-EB.

After qualitative correction of the statistical tests, the pre-service teachers discussed the results amongst themselves and with their advising professors and supervising teachers about , considering perceptions of failure and changes to the next application of these DS. For the in-service teachers the PIBID has been an opportunity for continued education. One of the supervisors, who had been in a state of great emotional distress about the profession, and had demonstrated great apathy in merely repeating former semesters, changed his attitude with the new activities proposed by the pre-service teachers and the reasoned response of the students, going to give suggestions and participate in more activities in general school.

It is therefore believed that the PIBID has provided important moments of training to pre-service teachers: in teaching statistical concepts that will be needed for teaching in the future, and providing opportunities to prepare and execute activities in the classroom with the guidance and supervision of professors and teachers, which gives greater security for pre-service teachers who are learning to teach.

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