PEDAGOGICAL TECHNIQUES FOR INCREASING MOTIVATION IN LEARNING STATISTICS. CASE STUDY FOR A ROMANIAN UNIVERSITY

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Abstract

Methods of teaching statistics have known an increased interest from both scientists and teachers, especially after the significant breakthrough of multimedia resources for educational purposes. The didactics of statistics has a special approach due to its mathematical nature and somewhat abstract side. This could lead to anxiety and particularly lack of motivation or enthusiasm from students for learning this subject.

The issue has been addressed in several studies. In the first part of the paper we propose a review of the literature in this matter, in what concerns the research done in the field of statistics education, the main concepts of learning statistics and the recent evolution of the methods for teaching statistics.

In order to find ways of improving students' motivation in learning statistics, the paper proposes a case study in which we try find out the students' perception on statistics and the ways to integrate real data in the current teaching context. The study is innovative in proposing a new manner in which students can be involved in the teaching process with the use of a dataset they relate to.

Key words: Pedagogic research, Teaching, Statistics.

JEL Code: C10, C18, C19.

Introduction

As stated by Libman (2010), the mission of the teacher should be to construct knowledge, not to reproduce information. In the same paper, Libman (2010) argues that the traditional methods for teaching and assessing statistics have been very criticized in the last years, due to the failure in helping students achieve profound understanding of the basic concepts and develop their thinking in such a way to enable them to apply the knowledge to new situations. The traditional methods have also been criticized for creating a rather complex and mathematical image for the statistics discipline, causing students to dislike the subject. In our

paper, we first identify the place of statistics between other disciplines – statistics is very important for adults in everyday life and also in certain industries, being a fundamental discipline, considering that data, variation and chance are an important and significant part of our modern lives (Gal, 2002). In the second part of the paper, we describe the main principles of learning statistics and in the third part we present the recent advances that have been done for methods of teaching statistics. Finally, we introduce our case study for finding the ways of improving students' motivation and we present the conclusions.

1 Statistics education

As pointed out by Garfield (2007), the research on statistics education is rather a fragmented discipline, due to the diversity of disciplines to which the studies on this topic are related and confined to a variety of disciplines, from sociology to mathematics or computer science. Attempts have been made for unifying these studies into a single expression space. In this context, multiple journals and conferences have been dedicated to the subject of statistics education, like the Statistics Education Research Journal (established in 2002) or the International Conference on the Teaching Statistics (ICOTS).

In their study, a very useful differentiation between statistical literacy, reasoning and thinking is done. The three levels of understanding and learning statistics are defined as follows:

- "Statistics literacy is a key ability expected of citizens in information-laden societies and is often touted as an expected outcome of schooling and as a necessary component of adults' numeracy and literacy", this it assumes understanding and getting to use the basic concepts and language of statistics and being able to make some interpretations of the data.
- "Statistical Reasoning – the way people reason with statistical ideas and make sense of statistical information". It means understanding and being able to explain statistical processes and to interpret the statistical results.
- "Statistical Thinking – involves a higher order of thinking than statistical reasoning". This is the way that professional statisticians think and it includes "knowing when and why to use a particular statistics method, measure and design a statistical model". The three level of knowing statistic are hierarchically distributed, as can be seen by their definition.

Regarding the statistical literacy, it is Gal (2002) that makes the largest research on this term and its implications.

1.1 Statistical Literacy

Gal (2002) comes up with a conceptualization of the statistical literacy term that we consider as the most complete and suggestive. Statistical literacy is the result of two components – the first one is "people's ability to interpret and critically evaluate statistical information, data related arguments and stochastic phenomena" and the second one is "the ability to discuss or communicate their reactions to such statistical information, such as their understanding of the meaning of the information , their opinions about the implications of this information, or their concerns regarding the acceptability of given conclusions". Considering the definition presented above, one can understand the importance of possessing the abilities to "translate" everyday statistical information. As stated by Gal (2002), most adults are consumers of statistical information (as opposed to producers), as we are all exposed to it, in different forms such as: media support (newspaper, internet, television, etc), polls, tables, charts, graphs, etc.

Starting from this assumption, Gal (2002) proposes a model for the knowledge base of adults. The model proposes a knowledge component and a dispositional one (consisting of beliefs and attitudes on one side, and critical stance on the other side). The knowledge component is comprised by five elements: literacy skills, statistical, mathematical and context knowledge, critical questions. This component acts as pre-requisites that should help understand why data are needed and how can be produces, increase familiarity with basic terms and ideas related to descriptive statistics, graphical and tabular displays, knowing how the inferences in statistics are reached and help understand basic elements of probability.

All this mentioned prerequisites are actually the core elements for the introductory course in statistics, also for college students. However, we should mention that in Romania, low attention has been paid to statistics in high-school curricula.

2 Principles and difficulties in learning statistics

2.1 Principles in learning statistics

Garfield (2007) gives the 8 main principles for learning statistics, which we try to summarize in what follows. Firstly, students construct their own knowledge about the contents taught by connecting the information to what they already believe. Secondly, students learn better if

they are actively involved in the process of learning and if they experience the contents in new situations. In the third place, most of the students find difficult to learn ideas of probability and statistics and the understanding of the basic concepts is often overestimated. Also, it is important to use technological tools to help students to visualize and explore data and not simply to follow some pre-defined algorithms. Last, but not least, students' performance improves when they receive permanent feedback.

2.2 Difficulties in learning statistics

In their paper, Tishkovskaya and Lancaster (2010) have summarized the identified problems found in teaching and learning statistics from the relevant specialty literature. They focused on a group of 10 studies, ranging from 1988 to 2007, written by leading statistic educators.

The main issues in learning statistics deal with the focus on mathematical and mechanical aspects of knowledge, the rather abstract side of the topic, inability of linking the concepts learned with problems arising from everyday life and inability to apply the aspects in order to solve problems in specific contexts. The math-phobia and statistics anxiety are also mentioned, as well as the lack of background in mathematics, probability and statistics, deficiencies in basic statistical knowledge and the lack of statistical literacy.

2.2 Main misconceptions in learning statistics

Castro Santos (2007) argues that inferential statistics is an essential topic in statistics, but subject to many misconceptions. The study is very useful in finding out the most common misconceptions that students hold in what concerns the inference. The author makes a thorough literature exploration, covering 15 years of studies providing empirical evidence of university students' misconceptions.

Most of the misconception deal with the law of large numbers and the variability of the sample mean. People tend to confuse the sample and the population distribution, extrapolating the law of large numbers to small samples (commonly called as believing in the law of small numbers). This is mainly due to the lack of insight in the idea of variability for the random events, contexts in which students should already have a background. Another misconception deals with understanding the difference between the distribution of the sample and sampling distribution of a statistic, and also about the central limit theorem and the normal distribution together with its theoretical nature. Also another part of the paper is dedicated to the difficulties in understanding hypothesis testing because it involves many abstract concepts, such as sampling distribution, significance level, null-alternative

hypothesis, the p-value. Most of the misconceptions regard the philosophy behind the test, the interpretations of concepts, results and the numerical value of the p-value.

3 Methods of teaching statistics – recent research

It is difficult to find the best teaching method due to the limitations in study design or assessment used. The studies cannot tell if a certain teaching method leads to significantly improved student outcomes, that evidence is not available in the literature, as the results of the research studies are usually limited to a certain course context and one does not have the premises to generalize it to other courses (Garfield, 2007).

As pointed out by Libman (2010), the reform in learning has become mandatory considering the increased market competition among higher education institutions. As the dynamics of the business world evolves so quickly, the skills students acquire during university may no longer be relevant once they begin their careers. Employers are asking for critical thinkers that are able to engage in effective problems from real-life, work in teams and communicate. Students have to be encouraged to personally develop and acquire knowledge that will reflect in the future needs that will be placed upon them.

Considering the reform in statistics, in the old pedagogy model, students learn by absorbing information and a good teacher transfers information clearly and at the right rate; in the new model, students learn through their own activities and a good teacher encourages and guides their learning (Moore, 2007).

3.1 Elements of the new methods in teaching statistics

As per Tishkovskaya and Lancaster (2010), the methods of teaching statistics should be "implemented as to enable students to receive training which is both up-to date and relevant to society needs". They summarize the main directions of the reform in statistics: the update of the contents in the statistics courses, reform in the didactic techniques and pedagogical methods and insertion of computer simulating methods.

The new methods of teaching statistics, as summarized by Tishkovskaya and Lancaster (2010), include some main elements: the integration of statistical literacy concepts in the curricula by means of explaining statistics facts encountered in everyday life; the use of media support in order to improve the statistical thinking and the use of problems with real-life data in order to increase students' motivation; designing the teaching process in a way that

students can be encouraged to talk about their misconceptions in statistical concepts; including statistical software in the form of simulation programs or online resources (applets).

3.2 Examples of new methods in teaching statistics – graphs, social media and games

Unwin (2000) argues that the bad reputation of teaching statistics could be overcome with the use of interactive graphics that can complement the statistical analysis, make the statistical concepts more visible and have the potential to "influence the whole range of statistics" by contributing in data analysis, as well as in making more clear the statistical theories. In his study, he approaches three examples with real-life data – an example with simple data analysis, one with an application of the t-test and a third one with regression. The author sustains the advantages in using intensively graphical representations: increase the motivation and interest, value added for the students who can understand why statistics is interesting.

In another study, Everson (2013) tries to find ways to motivate and engage the students by including social media into the classroom. The authors present some examples of using social media networks like Facebook, Twitter or YouTube into an introductory statistics course. A group on Facebook is created for all students in the course to join, creating a space where they can: post links to articles related to contents learned in the course, make a summary of an article in an academic journal or use the YouTube to create a short video with explaining some notions learned in the course to someone else. The authors draw attention on the way these social media channels are used, because they have their own culture, and trying to use them for something else may lead to making some mistakes. Social media may be used "as a way of getting students to participate in their learning experiences", in there is potential in "meeting the students where they are".

Rosmalen (2014) suggested using games for learning as an engaging way of helping students to learn. He argues that „...games offer methods of learning which are highly consistent with modern theories of effective learning which propose that learning activities should be active, situated, problem-based, interactive and socially mediated" and „can be a useful tool for Higher Education Institutions to develop and deploy, to enhance the student experience and to assist them in achieving the intended learning outcomes".

4 Case study

We asked each student in the class to fill in a questionnaire in order to find out their opinion about statistics. The students are from the Faculty of Finance, the Academy of Economic

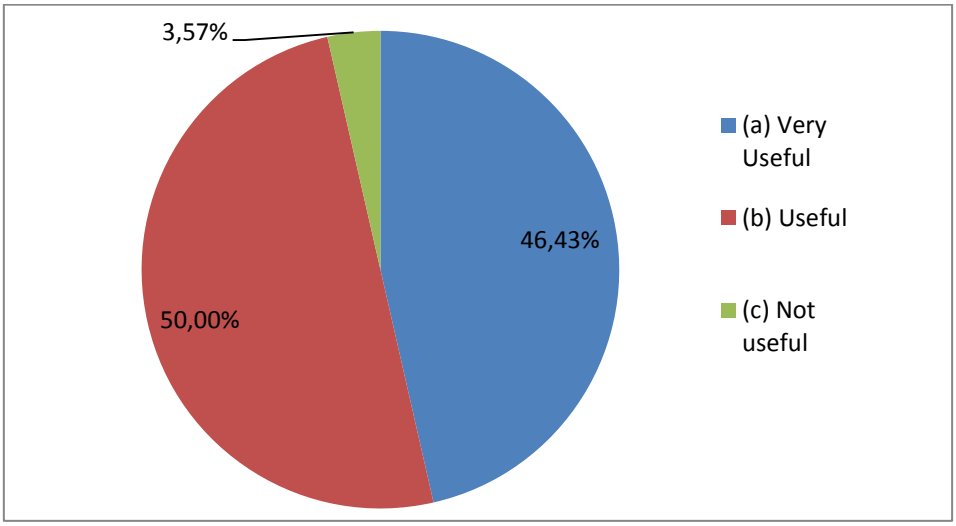
Studies, in their first year of study (average age about 20 years) and are the author's students for an introductory course in Statistics. The number of students which filled in the questionnaire was 143 (all of them students of the author).

The questionnaire comprised 5 questions: from question 2 we find out the perception of students regarding the subject of statistics. The results are centralized in figure 1. We find that a striking 90% of the students consider statistics as a useful and very useful subject, which is very promising and shows that the importance of statistics in daily life is correctly understood by students. However, only half of the students consider that they will apply the concepts learned in their future job – this may be caused by the problems used in the seminar with made-up data rather than with real data, causing students to have a distorted image about the way statistics could be used in real-life problems.

In the second part of the question we ask the students to grade the usefulness of statistics on a scale from 1 to 10. We find an average grade (also Median and Mode) of 8, which confirms the results obtained above.

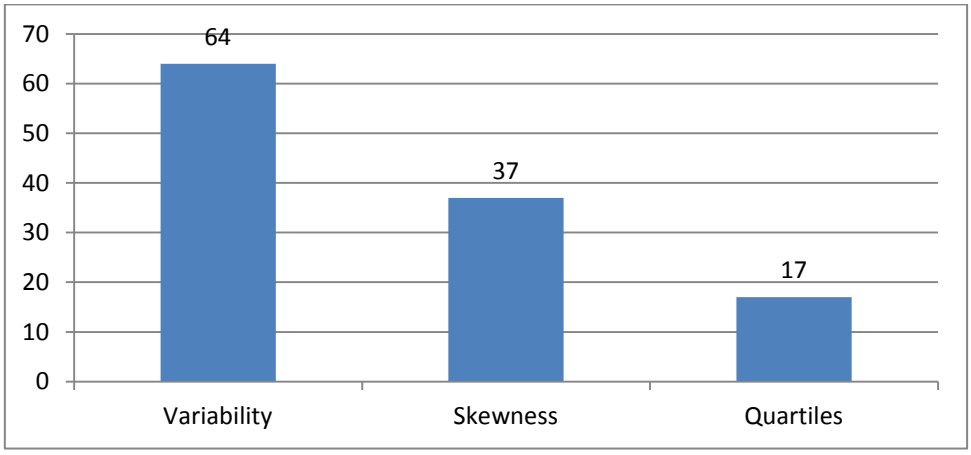
From questions 4 and 5 we find out the students' perception regarding the concepts learned. For question 4, we find that 61% of the students consider the concepts learned easy to understand and practical, while the remaining of 39% find them however abstract. Regarding question 5 (which concept was the most difficult to understand), only one student choose answer a) (the average), while the distribution of the answers for the remaining of the variants is depicted in Figure 2. The answers confirm what we found in the specialty literature (Garfield, 2007), that is the variability is the statistic concept students find most difficult to assimilate.

Fig. 1: Students' perception regarding the usefulness of statistics (centralized answers to question 2 in the questionnaire).



Source: processed data from questionnaires, own calculation.

Fig. 2: Students' answer to question 5 (concepts difficult to understand)



Source: processed data from questionnaires, own calculation.

With the answers from question 3 (grade received in Mathematics on the previous Semester of school) and with the grades obtained at an intermediate statistics test, we run a regression analysis in order to test the theory that considers the performance in statistics is determined by the numerical competence (Shiu, 2013). The results of the regression are found in Figure 3.

Fig. 3 – Regression Output between performance in a statistics test and the mathematic exam

Dependent Variable: STAT_TEST
Method: Least Squares
Included observations: 138 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.224169	0.385958	8.353673	0.0000
MATH_TEST	0.610637	0.059928	10.18950	0.0000

R-squared	0.432922	Mean dependent var	6.870290
Adjusted R-squared	0.428752	S.D. dependent var	2.248094
S.E. of regression	1.699131	Akaike info criterion	3.912497
Sum squared resid	392.6381	Schwarz criterion	3.954921
Log likelihood	-267.9623	F-statistic	103.8259
Durbin-Watson stat	1.963893	Prob(F-statistic)	0.000000

Source: processed data from questionnaires, own calculation.

We found indeed that the performance in statistics is determined in a significant proportion by the numerical skills (correlation coefficient of 0.658). However, the results show that we do not have perfect or close to perfect fit between the two variables, thus the performances of the students can be improved even though the mathematical background is not so good developed, and the ways of doing that is by increasing their motivation in learning statistics.

After gathering the data, we use them as didactic material in the class for the exemplifying the regression lesson. We use the two variables created by the students (math grade and statistics grade) and explain their correlation. We can see that the interest and the motivation of the students increase when using real-life data. Students are very interested and pay much more attention when dealing with data they can relate to and know that are real. This is in line with what we find in the specialty literature (see for example Shiu, 2013).

Conclusion

Developing statistical expertise can become challenging due to its abstract dimension requiring "the consideration of inter-related logical reasoning, critical thinking, data analysis and interpretation (…). Students perceive statistics as difficult and boring and this leads to anxiety and a lack of self – efficacy". (Rosmalen, 2014).

The present study is an attempt of finding out the perception of the students regarding the subject of statistics. We find out that the students perceive statistics as a very useful

subject. Our findings also confirm the ones in the specialty literature, that is the examples based on real-life data as opposed to the on made-up data are increasing the motivation and interest of students. As Unwin stresses, "students need to be able to explore, look at ideas from many different aspects and to investigate in depth".

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