GeoGebra as e-Learning Resource for Teaching and Learning Statistical Concepts

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Abstract: Understanding probability and statistics is essential in the modern world, where the print and electronic media are full of statistical information and interpretation. The probability and statistics lessons should provide to the students the ability to collect, organize and analyze numerical data, and to understand chance. Appropriate use of technology allows more students access to mathematical concepts in general and also to access statistical concepts. A number of software tools are available for solving and visualization of mathematical problems. GeoGebra, as dynamic mathematics open-source software, is attracting a lot of interest in the mathematical community. Spreadsheet, which enable statistics calculations, and probability calculator are features of GeoGebra that is not found in other dynamic mathematics software. In this paper, using GeoGebra will be created instructional materials that will solve several practical problems from the area of probability and statistics. Use of GeoGebra applets had a positive effect on the understanding and knowledge of the students.

Keywords: GeoGebra, e-learning, probability, statistics

1 Introduction

There is no doubt that probability and statistics are very important in variety of sciences as well as daily applications. Using statistics, the data are turned into knowledge. In the modern digital world, everything is about data. But, data without knowledge are useless. So, for every student regardless of his future profession, is essential to understand basic concepts of mathematical probability and statistics. This will be useful in technology fields as well as business in general, for reporting and understanding results.

In the modern educational process, use of technology is inevitable. There are a number of applications that can be used for solving statistical problems. Among them, we choose the application GeoGebra, because it is free, open-source and is very user-friendly. To demonstrate the real-life application of some of statistical parameters and methods, we use real data from the comparative analysis of handwriting among students with harmonious handwriting and their compeers with dysgraphia in elementary schools in Ohrid [1].

2   Practical Examples in Teaching and Learning Statistics with GeoGebra

In our study, we want to conclude is there a significant difference between the students' ability for writing (is their handwriting good or they have dysgraphia), depending on their gender and their age. For that purpose, we choose 37 students from the total of 238 students (this number statistically represents the *sample* of the population), which during the testing process (this process statistically represent the collection of data) shown that have dysgraphia (they got more than 14 point during testing), and we call this group of students an **experimental group**. This group consists of 33 boys and 4 girls. 13 of them are in second grade, 17 in third and 7 in fourth grade. On those data, using GeoGebra, we performed different statistical methods to make conclusion about data.

The solution of these problems consists of two parts. In the first solution we calculated means, medians and standard deviations and then performed appropriate tests to make conclusions about data. Second solution is a graphical representation of data, which consists of frequency tables and relative frequency histograms (we work with relative frequencies because the number of elements in the lists are not equal; for example we have 33 boys and only 4 girls).

2.1   Example 2 - Dysgraphia by Age in the Experimental Group during Dictation

The statistical question is: "Does the **age** have influence on the handwriting of the students in experimental group (the students that have dysgraphia)?"
To answer this question, we divided the students into three populations: in the first populations are students from second grade, in the second population students from third, and in the third population students from fourth grade. The sample data are grouped and are shown on Table 1:

Table 1. Grouping sample data according to age

grade	Handwriting points				total
	<10	10-13,5	14-19	>19	
second	0	0	3	10	13
third	0	0	17	0	17
fourth	0	0	7	0	7
total	0	0	27	10	37

Because in this case we have more than two populations, the *ANOVA* test is used. Using GeoGebra list command three lists are created, and for each list the mean, median and standard deviation are calculated. After that, the ANOVA test is run with following syntax: *ANOVA[<List>, <List>, ...]*. The obtained results are shown on Fig. 1.
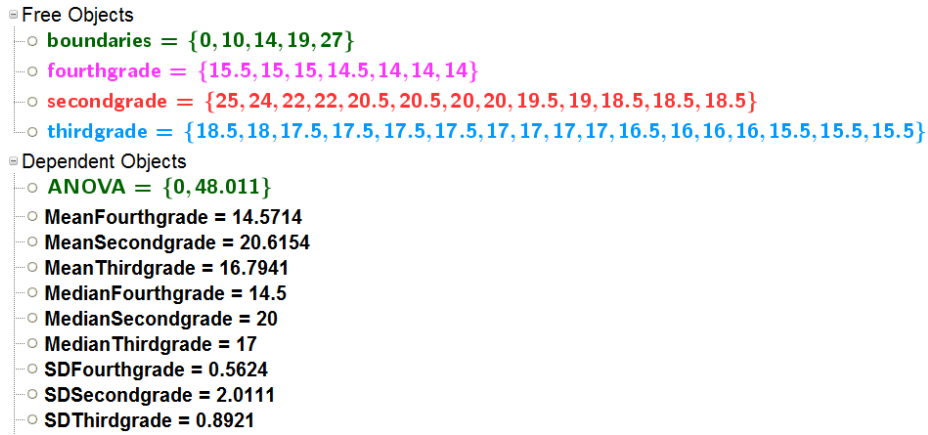
Fig. 1. GeoGebra algebra window with ANOVA test result

Result is returned in list form as {P value, T test statistic}. In our case the result is ANOVA={0, 48.011}. From this result we can conclude that by conventional criteria (P value = 0), this difference is considered to be **statistically significant**, which means that there is big difference between mean values of populations or, with other words, the age has significant influence on the handwriting of the students.

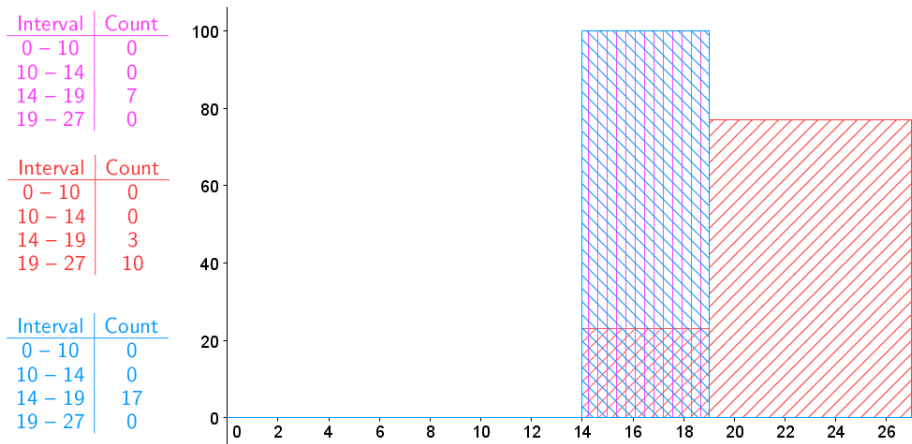To confirm this result, we drew frequency tables and histogram.

Fig. 2. Frequency tables and Relative frequency histogram in GeoGebra for three populations

By the histogram (Fig. 2) is confirmed the result obtained by ANOVA test. It is obvious that there is significant difference between three populations (second grade is represented with red color, third with blue and forth with pink color), which means that age have significant influence on the handwriting of the students.

The GeoGebra applet with short explanation is uploaded on: `http://www.geogebratube.org/student/m15074`

3   Conclusion

Learning probability and statistics is sometimes hard for students, because they need mathematics with many new and abstract concepts. It is very hard for them to make relationship between statistical theory and its application in solving different real-life problems. So, the way of teaching statistics is very important. This study is only a small contribution to students' understanding of basic statistical concepts in a new way, through visualization of statistical data, which contribute to better interpretation of obtained results.

GeoGebra has implemented a lot of statistical tools that offer possibility for solving a wide range of statistical problems. Also, the GeoGebra applet can be uploaded on GeoGebra tube together with the short explanation, which means that is available to the students for self-learning.

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