Inferential Statistical Analysis in E-Learning University Education in Latin America in Times of COVID-19

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Abstract. Since the appearance of COVID-19, the teaching-learning processes in higher education have changed. This article shows a focus on university education and e-learning, performing a statistical analysis on university students in Ecuador, obtaining significant evidence that the use of ICTs improves academic performance in the subject of statistics. In the first case, two third semester courses are taken, the experimental group is made up of 23 students, to which e-learning is applied and an application developed in Scilab that shows the resolution process for descriptive and inferential statistics; while the control group is made up of 14 students, in which only e-learning and traditional teaching are used. In the second case, 2 courses are taken, the first is formed by 14 students and the second by 22 students, using e-learning and traditional teaching. First, the Shapiro Test is used to determine if the population has a normal distribution, then the Student's T test is applied in the hypothesis test of difference of means to determine if academic performance is improved with the use of ICTs. Finally, for $\alpha = 0.05$, it is verified that the developed application improves academic performance. Another important finding is that only using traditional teaching with e-learning does not significantly change academic performance.

Keywords: E-learning · Scilab · Inferential statistical analysis

M. Botto-Tobar et al. (Eds.): ICAT 2021, CCIS 1535, pp. 97–107, 2022.
https://doi.org/10.1007/978-3-031-03884-6_7

1 Introduction

1.1 A Subsection Sample

Face-to-face education worldwide has had valuable representation due to the access to collaborative practices, experimental environments and the ease of interaction in real time between the teacher and students; But, this form of learning changed completely due to the Covid-19 pandemic, and despite the fact that virtuality has been an attractive form of study, it has strengthened in recent years.

Most of the University Education institutions have platforms for students to carry out autonomous work activities in synchronous and asynchronous time that undoubtedly helps the teaching-learning process, and the use of Information and Communication Technologies have become essential academic support tools. Research related to the use of E-learning platforms affirms that the application of e-learning education in universities allows the enrichment of teaching [1]. Currently, these institutions seek to technify their educational model to offer virtual services that facilitate the obtaining of information in a dynamic way with the support of quality teaching and with accessible programs that adapt to the needs of society.

E-learning as an educational environment originated with the appearance of internet networks and by the 70s it proliferated thanks to email, turning it into a communicational tool of a governmental and business type, and teleconferencing was the most common training mechanism. Used for staff training. In the 90s, virtual platforms for teaching emerged with basic contents that were not difficult to manipulate, since great knowledge was not required for their mastery. The new millennium accelerates the evolution of learning because technological innovation, a product of globalization, has made it possible to be at the forefront of the generation of content and new forms of instruction in developed countries.

At the Latin American level is where the need for pedagogical structures that ensure educational quality is most observed, therefore, the demand of the market for virtual education is to have instruments that allow them to learn in a meaningful way. Argentina, one of the pioneers in the creation of content through the use of internet networks in South America, analyzes the problem of the universalization of higher education and, through the Latin American Institute and the Quality Criterion in Distance Higher Education, defines that the evaluation and accreditation of education is key in virtual education, likewise it worries that traditional teaching based on empirical and theoretical compression does not allow objective evaluation, obstructing the generation of new learning paradigms [2].

The pandemic restricted face-to-face activities, affecting almost all social sectors and education in general was no exception. The measures to control the growth of contagions forced the University Education Institutions to opt for virtuality. At present, access to information is abundant since the internet has digital repositories and selective search engines to obtain quality content, however, that does not mean that education is better since other components

are required for the process of teaching-learning be successful. In a study carried out, the term engagement is used to express the integration of some factors such as the availability of ICTs, technological autonomy, behavior, competence and the interest of the learner [3]. E-learning is an educational alternative that is permanently contributing to the training of professionals committed to society and always renewing their way of teaching to meet market expectations.

It is essential that in post-pandemic education collaborative work is promoted through e-learning programs with the active participation of the teacher so that students feel supported and advised in a personalized way through the use of Information Technologies and Communication. It must be clarified that e-learning is not the same as distance education, its difference establishes that the first requires the guidance of a professional in the teaching area and the use of computational means, and the second may or may not use technology.

Contemporary educational technology uses illustrative applications to facilitate learning, favoring the development and organization of the virtual environment. Due to its flexibility to create interaction environments in synchronous time, the exchange of criteria makes the construction of knowledge more dynamic and entertaining, leading to obtaining more effective results. Another research contribution is expressed that the use of electrical means for the learning process is on the increase, in addition the use of computers for assisted teaching creates skills according to the needs of the market [4]. Undoubtedly, there is a favorable trend to use applications in teaching-learning processes since their dynamism, participation, collaboration and interaction are key elements of education in the 21st century.

Although it is true that technology has facilitated the creation of educational environments and a simpler access to knowledge, we continue to observe transitions that increasingly make the university education process more technical; This is where the pedagogical model must be clear, explicit and strengthened through the implementation of technological resources, teacher training and student adaptability. A publication on Education in Times of Pandemic (2020) states that E-learning, M-Learning and B-learning are increasingly used in the educational field [5].

Research is part of the activities carried out in university education, achieving representative results for society during the last decade. The development of digital technologies according to the World Conference on Higher Education in the XXI century encourages knowledge with the accompaniment of ICTs [6]. Currently, it is known that there is a favorable response capacity towards university initiatives to improve higher education, this thanks to the fact that through the use of innovative methods they are getting students to obtain meaningful and quality learning, counteracting the adversities of the environment that they affect not only the infrastructure and tools for the academy, but also the procedure used in teaching.

In an investigation carried out in Mexico and Costa Rica [7], using a Likert scale to measure the integration of ICTs in university students, it was determined that the use of ICTs is valued but they are exclusive with people who do not have

mastery in these fields. In Ecuador there are initial studies that try to measure the perception of ICTs in a quantitative and descriptive way [8], it is imperative to ask the question Do e-learning education and ICTs tools improve university education?

2 Materials and Methods

To perform the inferential statistical analysis, both confidence intervals and hypothesis tests can be used [9], with confidence intervals being more used. However, in the present study it is used as average data of grades in a subject, for which a test of the hypothesis of difference of means was used, such as the study carried out in Guadalajara [10].

In the present investigation has been realized the following stages:

2.1 Application Developed in Scilab

The use of ICTs improves knowledge management [11], which is why an application was developed using the free software Scilab, which added to e-learning, created a virtual learning environment, to ensure that education adapts to the needs of the non-contact work of the students [12]. This tool allows you to visualize the process of developing problems, both for inferential statistics and descriptive statistics, because most programs such as Matlab, SPSS, R, Python, etc., only show the result. There are online programs that also solve statistical exercises, such as Symbolab or Wolfram, but that require a paid subscription to view the resolution of exercises.

To achieve the exercise resolution visualization effect, the data entered by the user in numerical variables are acquired, then they are processed according to the required statistical operation, and then the value obtained is stored in variables as a character string. Finally, the results obtained with both the mathematical signs and the grouping signs involving the operation are concatenated and they are shown as if they were a single character string.

In Fig. 1 you can see the descriptive statistics part allows the calculation and development of the process for calculating measures of dispersion, central tendency and frequency tables.

Also in Fig. 2, specifying the number of classes can be obtained polygon graphs of frequency or pie diagram. In Fig. 3 you can see the inferential statistics part allows to solve hypothesis tests when the variance is known (Standard Normal Distribution Z) as well as when it is unknown (T Student). When it comes to tabulated data in Excel it can be imported.

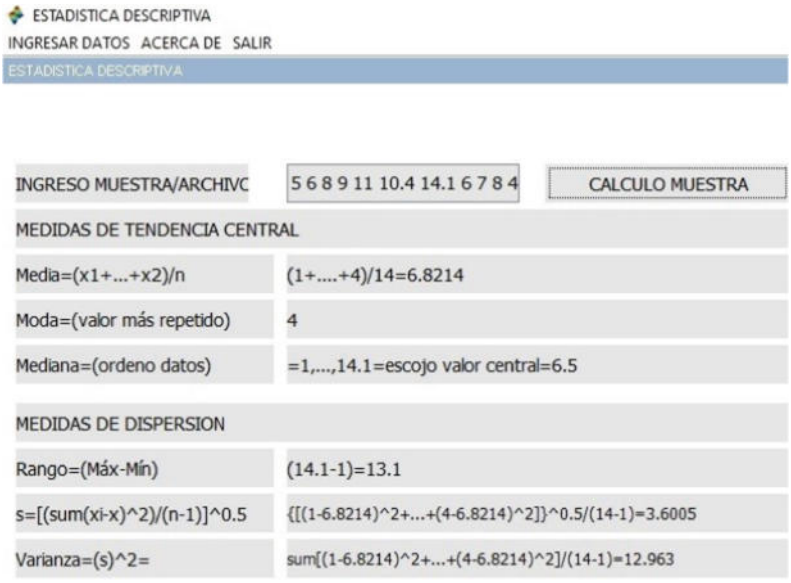

Fig. 1. Functioning of the application in descriptive statistics.

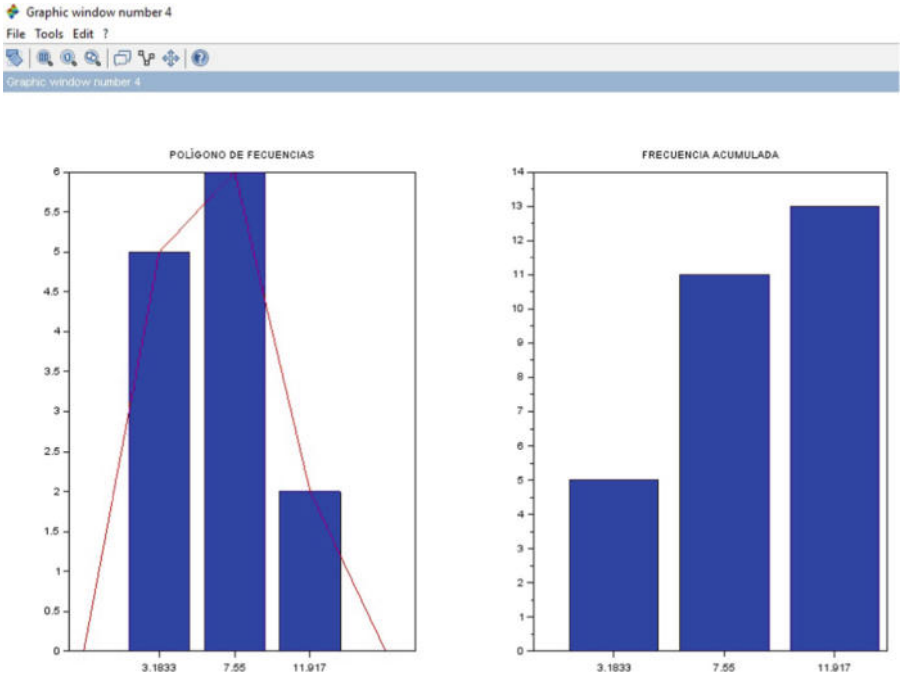

Fig. 2. Functioning of the application for graphics.

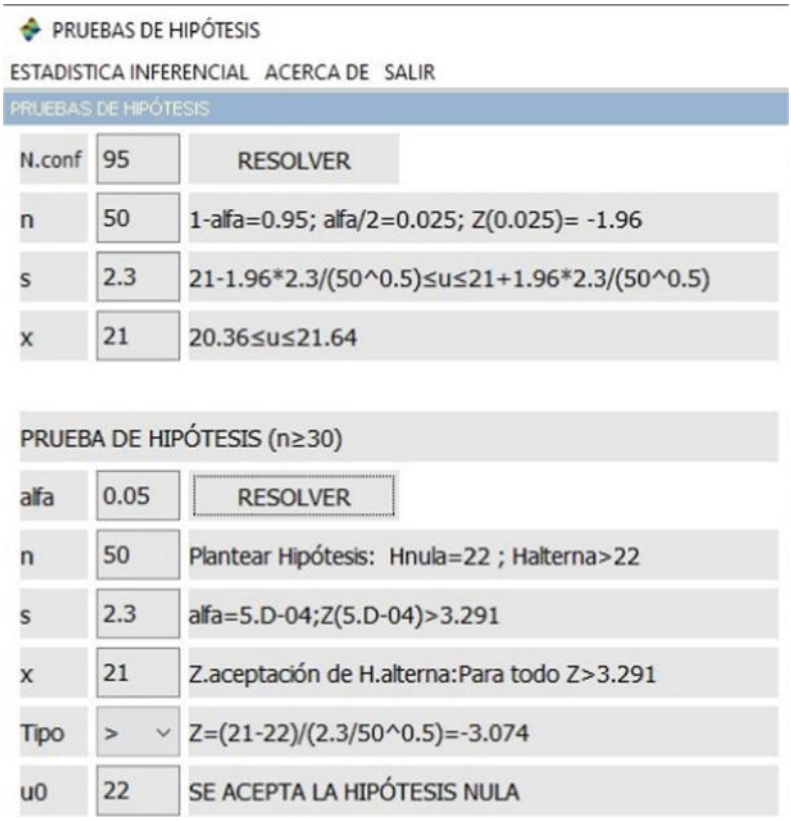

Fig. 3. Functioning of the application in inferential statistics.

2.2 Data Collection

The data were taken from four third semester courses, in an Ecuadorian University, in which the subject of statistics is taught. It is determined as an experimental group, to the course that teaching with ICTs is applied through an application developed in Scilab; while the control group is the course that uses traditional teaching.

2.3 Hypothesis Testing in Groups with Use of ICTs

In this stage, averages of students from various courses before and after the pandemic caused by COVID-19 were analyzed, specifically in the academic period September 2019-January 2020 and the academic period May-September 2020. It is important to note that the population analyzed in this study were students, unlike other studies carried out in the region, such as in Colombia, in which the study population was teachers [13].

The samples belong to two independent populations, that is, the averages of two different courses are handled, the first of 14 students and the second of 23 students, likewise, the first corresponds to the course before the pandemic and the other after the pandemic, but that they received classes with the same teacher, in the matter of statistics. To avoid atypical data, data belonging to students who withdrew from the subject are eliminated. The first group is the control group because traditional teaching is used, without the use of Tics, while the second group is the experimental group, with which, apart from using an e-learning teaching, the developed application was also used.

As the first part of the statistical analysis, it is verified that the data used belong to a population with a normal distribution. Then, a mean difference hypothesis test was carried out to verify if the use of e-learning and the application developed improved the performance of students, before and after the pandemic caused by COVID-19. This analysis was carried out with the R software. The result is shown in Table 1:

Table 1. Comparison of the average in the experimental and control groups with ICTs.

	Control group	Experimental group
Epoch	Before the pandemic	After the pandemic
Shapiro test	$p - value = 0.1509$	$p - value = 0.2937$
T test	$p - value = 0.0006508$	

As can be seen in Table 1, when applying the Shapiro Test to the control group, the value obtained is $p - value = 0.1509$, with which it is verified that it has a normal distribution, while in the experimental group a $p - value = 0.2937$, that is, it also has a normal distribution.

In the T student test, the value obtained is $p - value = 0.0006508$ for an $\alpha = 0.05$, so it can be concluded that the use of virtual environments, that is, use of the application developed in Scilab and online education, improved the average in the subject of statistics.

2.4 Hypothesis Testing in Groups Without Use of ICTs

The samples belong to two independent populations, that is, the averages of two different courses are handled, the first of 14 students and the second of 22 students, likewise, the first corresponds to the course before the pandemic and the other after the pandemic, but that they received classes with the same teacher, but different from the previous groups, in the matter of statistics. To avoid atypical data, data belonging to students who withdrew from the subject are eliminated. Traditional teaching is used in both groups, but e-learning was necessary for the second group due to the pandemic.

As the first part of the statistical analysis, it is verified that the data used belong to a population with a normal distribution. Then, a mean difference hypothesis test was carried out to verify if only with online education there are significant changes in student performance, before and after the pandemic caused by COVID-19. This analysis was carried out with the R software. The result is shown in Table 2:

Table 2. Comparison of the average in the groups without ICTs.

	First group	Second group
Epoch	Before the pandemic	After the pandemic
Shapiro test	$p - value = 0.4772$	$p - value = 0.2963$
T test	$p - value = 0.5939$	

As can be seen in Table 2, when applying the Shapiro Test to the group before the pandemic, the value obtained is $p - value = 0.4772$, with which it is verified that it has a normal distribution, while in the group after the pandemic pandemic, a $p - value = 0.2963$ was obtained, that is, it also has a normal distribution.

In the student T test, the value obtained is the $p - value = 0.5939$ for an $\alpha = 0.05$, so it can be concluded that only with online education and using traditional education, that is, without the use of the application developed in Scilab, there is no evidence that the statistical averages are different before and after the pandemic.

3 Results and Discussions

The first statistical inference shows that the average of the course (after the pandemic) that received statistics classes improved compared to the course (before the pandemic) that received classes in a traditional way, obtaining a $p - value = 0.0006508$.

For the second statistical inference, technological tools that help to improve the teaching-learning process of the subject of statistics were not used, but rather the same traditional teaching, but online. The result obtained, $p - value = 0.5939$, indicates that there is no significant difference in the averages of the courses.

In the study carried out in Portugal on a virtual platform [14] to improve the subject of statistics, it is mentioned positively in a qualitative way how students show interest in said platform, however, it lacks content and only shows previously developed exercises.

In Spain, at the University of Zaragoza [15], to improve the teaching of statistics, e-learning is used through a platform with videos, mind maps, videoconferences, tutorials and gaming. To measure the degree of effectiveness of the

teaching-learning process, student satisfaction surveys are used. This platform only allows interaction between teacher and students.

In Ecuador, specifically in the province of Azuay, both active methodology and ICTs [16] were used to improve mathematics learning. To determine if this methodological proposal was useful, surveys were conducted with students, obtaining positive comments from the students. No app was developed in this study, nor is there significant evidence of improvement in education.

Other investigations carried out, for example, the one carried out in Colombia [17], focus qualitatively on analyzing teachers who teach mathematics subjects and the use of ICTs in the teaching-learning process. Like the previous research, a specific tool is not developed that contributes to education.

In Peru, a mixture of techniques is used, among them Blended-Learning, Tics and Constructivism [18] to contribute to the teaching of statistics. Basically what is done is a teaching that motivates the use of tics so that students have more resources available in their university education. However, it must be emphasized that a specific tool is not used, but rather a set of options that allow finding the answer to a certain statistical problem.

Other studies try to determine the use of ICTs tools, for example a study carried out on university students in Mexico [19], the use of these tools was analyzed while for university students in Peru [20] it was tried to measure the degree of relationship of use of ICTs.

4 Conclusions

E-learning allows teaching in university education, however it does not mean that academic performance improves, in the case of study, the average of two courses was practically the same.

The incorporation of ICTs tools such as the application developed in Scilab, allows not only to develop exercises but also to improve academic performance, which was demonstrated with a hypothesis test.

It is important to mention that it has been statistically shown that the use of Tics improves average learning in university students, in addition, in the present study it was also shown that the use of Tics with traditional education does not improve academic performance.

The incorporation of new technologies and the applications that can be developed improved the teaching-learning process in higher education, thereby achieving the proposed objective of this research.

Data Availability: R code and data used in this study is available in: https://drive.google.com/drive/folders/1YqE4qSVqEzT0VjAaYfYVxOF3qzuy3b3h?usp=sharing

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