IMPLEMENTATION OF A TOOL FOR ANALYSIS IN INFERENTIAL STATISTICS IN HYPOTHESIS TESTING WITH KNOWN VARIANCE

IMPLEMENTATION OF A TOOL FOR ANALYSIS IN INFERENTIAL STATISTICS IN HYPOTHESIS TESTING WITH KNOWN VARIANCE

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Abstract **--** Today, students take advantage of ICT to check, find, or compare results from their math exercises. To do this, they look for software that is accessible, easy to use, and inexpensive. In this article, we find software that has these qualities for inferential statistics and, more specifically, for hypothesis testing: MINITAB 18. We carried out a detailed procedure using MINITAB 18, in which we showed students the steps for obtaining a hypothesis test in any of their cases. We demonstrated that this application is extremely helpful in reducing analysis and result times, regardless of the problem we have and intend to develop.

Keywords **--** Standard deviation, Statistics, Hypothesis testing, ICT.

Abstract **--** Nowadays, students take advantage of ICT to verify, find, or compare the results of their math exercises. For this, they look for software that is accessible, easy to use, and affordable. In this article, we explore software with these qualities for inferential statistics, specifically in the topic of hypothesis testing. This software is MINITAB 18. We provide a detailed procedure for MINITAB 18, guiding students through the steps to obtain a hypothesis test for any of their cases. We demonstrated that this application is a great help in reducing analysis and results times, regardless of the problem we are trying to develop.

Key words **--** standard deviation, Statistics, Hypothesis Testing, ICT.

INTRODUCTION

In various articles, we can see that during the pandemic, teachers found ICTs to be very useful for staying in touch with students more easily and improving learning when there was no face-to-face contact [14].

One of the difficulties students encounter when taking mathematics courses is not being able to know the results of the exercises until the teacher tells them [38]. A related problem is when students have already completed their exercises but cannot check their answers with the teacher because they are not in direct communication with them, perhaps because it is homework, an exercise to take away, or, in the worst case, because they are embarrassed [1].

Currently, there are a large number of information technologies (IT) that students can take advantage of once they have prior knowledge of the subject [17]. For example, there are applications that they can download to their devices and use to check their results on a topic covered in class [11].

In recent years, Artificial Intelligence (AI) has improved to such an extent that today there are different applications such as

- ChatGPT, conversational artificial intelligence developed by OpenAI [32].
- Gemini, an artificial intelligence with language modeling, made by Google [40].
- Copilot, artificial intelligence designed for programming, developed by OpenAI [26].

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- DALL·E, artificial intelligence for image construction, produced by OpenAI [20].
- Siri, voice assistant artificial intelligence, developed by Apple [15].
- Alexa, artificial intelligence that understands and responds to requests, developed by Amazon [34].
- Code Llama. Artificial intelligence for developing code, from Meta [21].
- MidJourney, artificial intelligence produced to create art, but digitally, made by an independent laboratory [2].

Through AI, you can solve a wide range of problems, from basic math operations [9] to complex mathematical analysis calculations. You can also edit images and customize them according to your needs [3], as well as engage in conversations with one of these AIs, which will respond based on your questions [27]. However, at some point, these artificial intelligences can make mistakes, as has happened in different cases, for example, in solving differential equations [6] or in images created with errors such as deformed faces or errors in shadows or reflections [16], and even in some questions about recent events (since it has not been updated to recent times) [18].

Thus, we still need to have one of these in our group of applications to help us find correct and easy-to-use results; because after all, AI has errors that can prevent our problem from being solved correctly [39].

Throughout their studies, many students encounter the subject of inferential statistics, where one of the fundamental topics is "hypothesis testing." There are different programs that can be used to check different hypothesis tests, to name a few

- MINITAB is an application that allows you to perform statistical analysis, developed by Minitab, LLC [33].
- IBM SPSS (Statistical Package for the Social Sciences) is an application used in statistics and data mining, made by IBM (International Business Machines Corporation) [4].
- EXCEL is an application that uses spreadsheets and data analysis, and is a brand of Microsoft Corporation [23].
- MATLAB (an acronym for MATrix LABoratory) is an application used in numerical calculation and simulation, developed by MathWorks [25].

This article will use the MINITAB program, which is very versatile, easy to use, inexpensive, and fast [31]. Thanks to the wide range of options available in MINITAB, a series of steps can be used to calculate different statistics.

Figure **1**. *MINITAB icon.*
Source: MINITAB screenshot.

Some important features of MINITAB are:

- Statistical Analysis. Hypothesis testing, descriptive data analysis, and confidence intervals can be performed [22].
- Regression and Modeling. It allows you to perform linear and nonlinear regressions, analysis of variance, and correlation analysis [29].
- Quality Control and Six Sigma. It contains process capability analysis and control chart tools.
- Data Visualization. You can create graphs such as histograms and scatter plots, as well as Pareto charts and Ishikawa diagrams [7].
- Multivariate Analysis. You can perform principal component analysis and cluster analysis [10].
- Simulation and Nonparametric Tests. You can perform data simulation, normality tests, and nonparametric methods [13].
- Automation and Macros. Repetitive analyses can be automated with scripts and macros [19].

A hypothesis test, also known as hypothesis testing, is the statistical process used to make decisions based on sample information, i.e., making a decision about a population based on a sample of data. By comparing the theoretical value, the null hypothesis ($H_{(0)}$) is either rejected or accepted.

The opposite of the null hypothesis is called the alternative hypothesis (H_1), i.e., it is a development that allows you to verify whether there is sufficient evidence in the data to accept or reject a statement (hypothesis) about a population. See [30].

The development involves several steps, such as proposing the hypothesis, choosing the significance level, collecting data, and concluding the results. If the sample results are "consistent enough" to reject the null hypothesis, then the alternative hypothesis will be accepted; otherwise, the null hypothesis will be accepted and the alternative rejected.

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These tests are fundamental in many subjects, especially in research, to approve theories and make deductions based on data.

There are different hypothesis tests, which depend on the types of data and the essence of the hypothesis. Let's look at some of them:

- Hypothesis test for a mean (Student's t-test). This is used when the sample is small and you want to compare whether the population mean is equal to a numerical value [24].
- Hypothesis testing for a proportion (z-test). This is applied when the sample size is large and determines whether the proportion of a representative in a population is equal to a numerical value [5].
- Hypothesis testing for two means (t-test for independent samples). Used when comparing the means of two independent groups [28].
- Hypothesis test for variances (F test). Used when comparing the variances of two or more groups and checking whether the differences in the variability of the groups are statistically significant [37].
- Chi-square test (χ^2). Used to compare analyzed frequency distributions with expected distributions, especially in data arranged into categories.
- Hypothesis test for two proportions (z-test for proportions). Used when comparing two proportions from different groups or samples [8].
- Hypothesis test for regression (t-test for regression). This is used to check whether the coefficients of a regression are significantly different from zero [35].
- Hypothesis testing for the difference between means (paired t-test). Used to compare the means of two related groups [12].

With the aim of calculating hypothesis tests (with known variance), this will be done using the MINITAB program (version 18) [36]; this paper will teach the steps to follow to do so.

Figure 2. *MINITAB version 18.*
Source: MINITAB screenshot.

DEVELOPMENT

1. When starting the hypothesis test, the population parameter (mean μ), known or unknown population standard deviation (σ), test statistic (mean $\bar{X}$), and number of samples must be taken into account.

2. There are three types of hypothesis tests:

a) Left-tailed test (tail on the left).

b) Right-tailed test (tail on the right).

c) Two-tailed test (two tails).

In this study, we will perform the population mean test (μ=8.1) with known population standard deviation (σ=2.01), one-tailed right (right tail (b)) and one sample (the other types of tests (a) and (c) are similar).

3. Open the Minitab 2018 statistical tool.

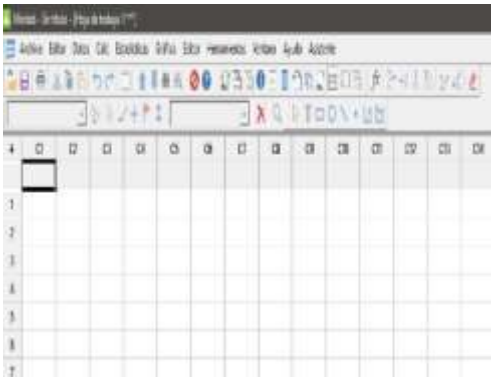

Figure **3.** *MINITAB 18 startup window.*
Source: MINITAB screenshot.

4. Save the project, name the document to be created, and save it in the desired folder.

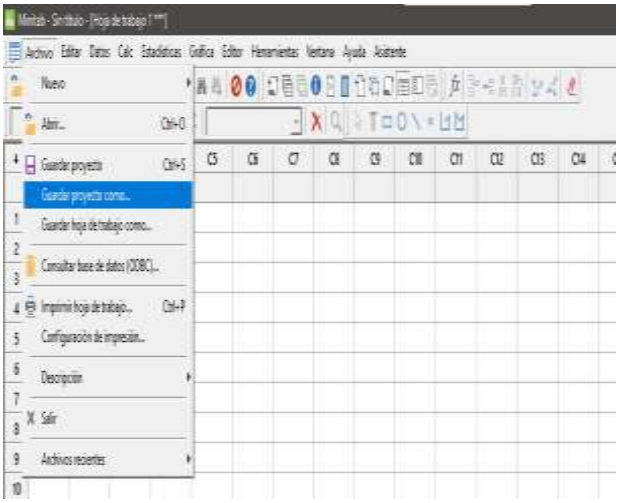

Figure 4. *Save Project option.*
Source: MINITAB screenshot.

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5. In the worksheet, edit the sample data. You can do this by copying each piece of data into each of the cells in the column of your choice, or you can use the application's feature to paste all the data when copying it from an external file (such as Excel). We suggest pasting or copying the data from the top of the column of your choice.

Once you have all the data, you can choose from a wide range of statistics to extract, but in this article, we will focus on hypothesis testing.

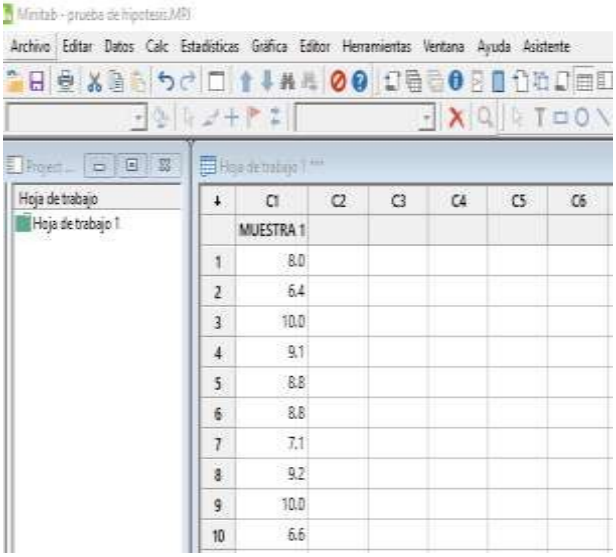

Figure 5. *Worksheet, Sample 1.*
Source: MINITAB screenshot.

6. Select the Statistics tool, Basic Statistics, Z from a Sample. See the following figure, which shows each of the options mentioned in the step.

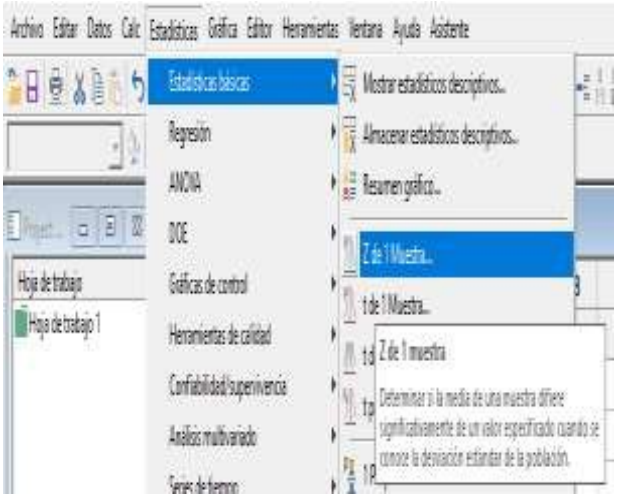

Figure 6. *Basic Statistics window.*
Source: MINITAB screenshot.

7. Select the data column (select) and in the dialog box, the data is in one column and

If this is the case, edit the population standard deviation (2.01), choose to perform the hypothesis test, edit the hypothetical population mean (8.1), choose options, and a window will pop up. Edit the confidence level (95.0). Select the alternative hypothesis (mean greater than the hypothetical mean), click Accept, and then Accept again.

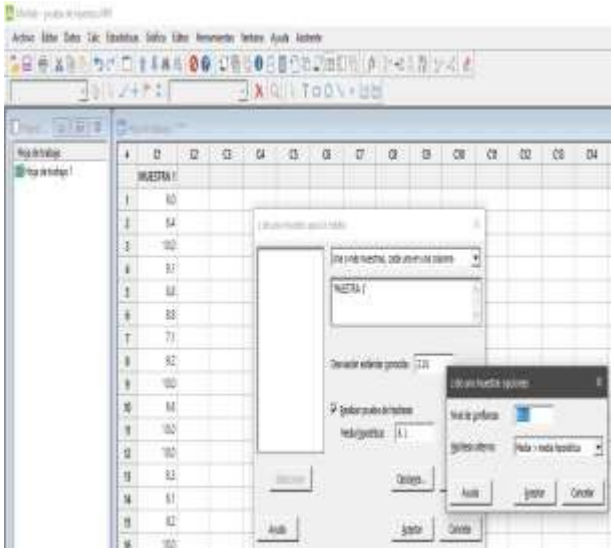

Figure 7. *Hypothesis Test Selection.*
Source: MINITAB screenshot.

The results are found in a session folder, which opens automatically, but this may take some time depending on the memory available on the PC or laptop being used, although on more up-to-date computers this is done without any problems, as their performance is improving every day.

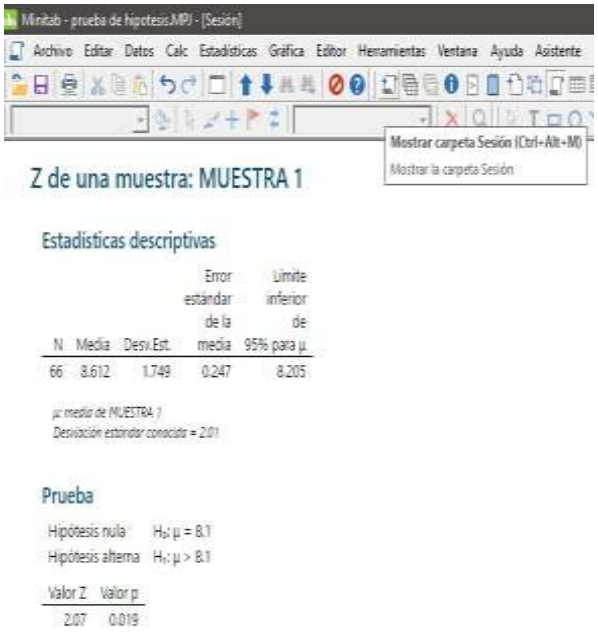

Figure 8. *Results window.*
Source: MINITAB screenshot.

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8. A decision is made based on the results obtained from the program. In this example, the following is acceptedH_O .

DISCUSSION AND ANALYSIS OF RESULTS

Taking into account the results obtained in the grades for the topic of Hypothesis Testing in the subject of Inferential Statistics, we note the improvement that exists in one group that took normal classes and another group that was added to the Minitab 18 program. The percentage of students who passed was higher in the second group. This is largely due to the fact that the experimental group was able to do more exercises and practice problems and verify their answers.

Compared to artificial intelligence (AI), the application leads to more reliable results, given that AI today is subject to continuous learning, which has not surpassed the development of large applications made by leading professionals in the corresponding field.

After the COVID-19 pandemic, students learned to be more self-taught because they did not have the attention of the teacher that they had in the classroom, so many students looked for other options to check the math problems they were given in class. In this way, applications are a good option for verifying solutions to math problems.

In this article, we focus on a single case of hypothesis testing, which is when we know the variance, but there are other variants. Even so, given the ease of use of the MINITAB 18 application, it is very simple to perform the other test cases, because these variants are very similar.

This MINITAB 18 program is the most comprehensive and accessible program that engineering students can have for solving hypothesis testing problems.

It is recommended that, going forward, the school pay for a license in order to reach more students who take the inferential statistics course, thereby improving learning through the use of this powerful tool.

CONCLUSIONS

Computer applications make mathematical calculations easier and faster, and hypothesis testing is no exception. Where we may take a little longer is in learning how to perform the steps to calculate the statistic, but once we have learned how to calculate it, it is very quick and accurate.

At the beginning, we looked at some of the applications that exist today that can help you find the required result for the problem you are facing (in this case, a hypothesis test). In carrying out this evaluation, we considered the ease with which you can obtain the solution, the cost of purchase, and the reliable performance on simple computers. This study concluded that MINITAB was the optimal application that met these requirements.

Through MINITAB 18, students can verify the results they obtain in examples or exercises seen in class or assignments. Students also gain confidence in the subject of hypothesis testing, as having an additional tool provides them with an easy way to find out the results without having to ask the subject teacher directly.

Once introduced to the program, students quickly and easily learn how to use it, given the simplicity of its commands and the clear and precise explanation of the steps to follow provided in this article.

In principle, hypothesis testing should be done manually or in writing. Subsequently, you can use this type of application to check or perform it more directly or quickly, but you can also choose to do it by developing the operations in a program such as Excel.

Now, to perform the other types of hypothesis testing that we saw in the introduction, modify the options for the one you are going to perform and enter the data that will be used. It is not very difficult to do, once you have done it one way, doing it another way is easy, since it does not vary much. So we have provided a starting point for students to take their first steps and then follow them.

We should also mention that there are more advanced versions available, such as the latest version, MINITAB V.22, although the version used in this work was version 18.

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