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A didactic proposal for teaching statistics in administrative careers

Miguel Andrés Díaz Osorio, "Universidad Antonio Nariño", ORCID: https://orcid.org/0000-0001-9943-3663
Orlando García Hurtado, "Universidad Distrital Francisco José De caldas", ORCID: https://orcid.org/0000-0002-4155-4515

ABSTRACT-This paper aims to show that by means of a didactic proposal about the teaching of statistics, it is possible to construct the robust meaning of volatility in a course of inferential statistics for careers in administrative sciences, accounting and financial by using innovative strategies such as gamification and problem solving through Excel simulations;in addition, statistics on important decision-making, in particular in the economic framework, are shown in a practical way, designing pedagogical strategies that make it possible to use important applications through the use of computer-assisted teaching techniques, the construction of abstract statistical and mathematical concepts such as volatility and the metrics that allow their evaluation. This project was carried out at a Colombian university and was applied to students studying inferential statistics in the aforementioned careers.

KEYWORDS: Didactic proposal, volatility, challenge problems.

I. INTRODUCTION

The expansion of statistics as a research discipline has been significant in recent decades and part of that process stems from the concern of human beings to obtain more information contained in the data that will enable them to improve their decision-making capacity. In particular, in the world of finance, predicting the behavior of investments, achieving "certainty" that good business has been done, discarding potential losses and thereby protecting the assets and livelihoods of families, is important in the daily lives of entrepreneurs.

This relevance of statistics as a decision-making tool can be seen in the quote from Varían (2009), when interviewed as Google's chief economist in 2009, he described the importance of statistics expressly:"...The ability to take data to be able to understand them, to process them, to extract value from them, to visualize them and finally to communicate; it will be an important skill in the coming decades, not only at the professional level, even at the educational level for primary school..."[1].

It is indisputable that the abundance of data in the business environment means that those who have the ability to interpret them correctly, have a clear competitive advantage over the other players in the market since the scarce factor is considered is the ability to understand the value of data beyond the abundance of it.

The free data, the large amount of data and the easy access of anyone, makes statistics a discipline of great development in recent years. However, although the data is available, there is still a constraint in terms of analysis as the methods applied to the teaching of statistics have left a generation of professionals in different areas waiting to apply models under "appropriate" conditions. Given that these conditions are rarely conducive to the application of such models, statistics remain in the classroom.

Frame of Reference

One of the important references of research is the **realistic mathematics** proposed by Freudenthal, H. (1991), because the data used for the simulation exercises come from real life. The principles of realistic mathematical education are the follow:

[1]Varían (2009), Tomado de: "Hal Varian on how the Web challenges managers", .Mckinsey& Company. Recuperado de: https://www.mckinsey.com/industries/high-tech/our-insights/hal-varian-on-how-the-web-challenges-managers el 7 de noviembre de 2017.

1. Principle of activity: This trend of mathematical education considers that Imparting mathematics is *"backwards"*, because traditionally theory is dictated and after that some daily application is sought to that which was learned. On the contrary, he states that the teaching of mathematics must be the product of an analysis of everyday situations and from there take what can be modeled, in a process called: *"Mathematization"*, then in the model it is proposed to start with the problem and from there the implicit meanings are built in each of the activities, encouraging that this construction is robust.
2. 2. Principle of reality: Take the problems of everyday life and from there, in its reality, seek to model through the contents of the subject.
3. Reinvention principle: *"Experiences of common sense crystallize into rules for example the commutativity of the sum and these rules become a new common sense..."*[2].It is clear the quotation made, by the experiences coming from the everyday that are mathematised, are already part of the reinvention as being thinking and critical of their environment and daily life.
4. Principle of the levels: Two dimensions are distinguished in the mathematization: mathematize horizontally consists in turning a problem of reality into a mathematical problem making use of common sense.

Mathematize vertically consists in moving within itself of mathematical reality in a more rigorous way as described by Bressan (2004).

It is referent of research, to identify such levels of mathematization, in order to define if there really was construction of meaning.

The second important reference is **gamification in education**. For our research, the Market Watch Game[3] of the New York Stock Exchange is proposed, this is an excellent scenario for students to correlate all statistical knowledge in a real environment. The game is simulated by an assisted platform that grants the participant a certain amount of money so that they have the possibility to invest in shares as if they were actually on the stock market since the consequences of their movements are reflected at the next day with increases or decreases in its initial capital. The goal is to get the best return versus other participants. The situations in context are defined hereinafter taken from Freudenthal, who defines them as a "*Domain of reality which in a certain learning process is revealed to the student to be mathematized*"[4] and this is the way to express said theory, through the already very realistic game. As for the theoretical bases of gamification are mainly adapted from Huang (2013) and Suh (2018) among other authors.

II. METHODOLOGY

Because this work is based on mathematical education the methodology used is under a qualitative approach and the theoretical foundations of action-research, since the main objective is to improve the quality of an action, in this case education through robust construction of theoretical and practical meanings.

Scope of the investigation

It is intended to promote the construction of robust meaning of the concepts associated with volatility in students and that at the same time they are able to interpret the scientific literature of the topic and thus contribute to their future professional performance.

Population and Sample

The study population consisted of students from the Antonio Nariño University in Bogotá Colombia, and the sample consisted of two distinct groups of students from the fourth semester of economic, administrative and accounting sciences who study the statistical subject II, one at Headquarters 1 and one at Headquarters 2. The students at Headquarters 1 are from a course taught from 8 to 10 pm Tuesdays and Thursdays; all are workers who in the evening attend the University; and those at Headquarters 2, are attending a course from 7 to 9 am Tuesdays and Thursdays; Students in this group are younger on average

[2]Bressan, A., Zolkower, B. E. T. I. N. A., &Gallego, F. (2004). Los principios de la educación matemática realista. *Reflexiones teóricas para la educación matemática*. P. 82.

[3] Simulador de la bolsa de valores de Nueva York. https://www.marketwatch.com/

[4]Freudenthal, H. (1991). Revisiting Mathematics Education: *China Lectures, Kluwer, Dordrecht, Reidel Publishing*Co.p73

than those in the other headquarters and most are not workers, they only study. The type of sampling is chosen for convenience, as indicated in Casal (2003).

The model used for the development of the course and the achievement of the proposed goal is shown graphically below:

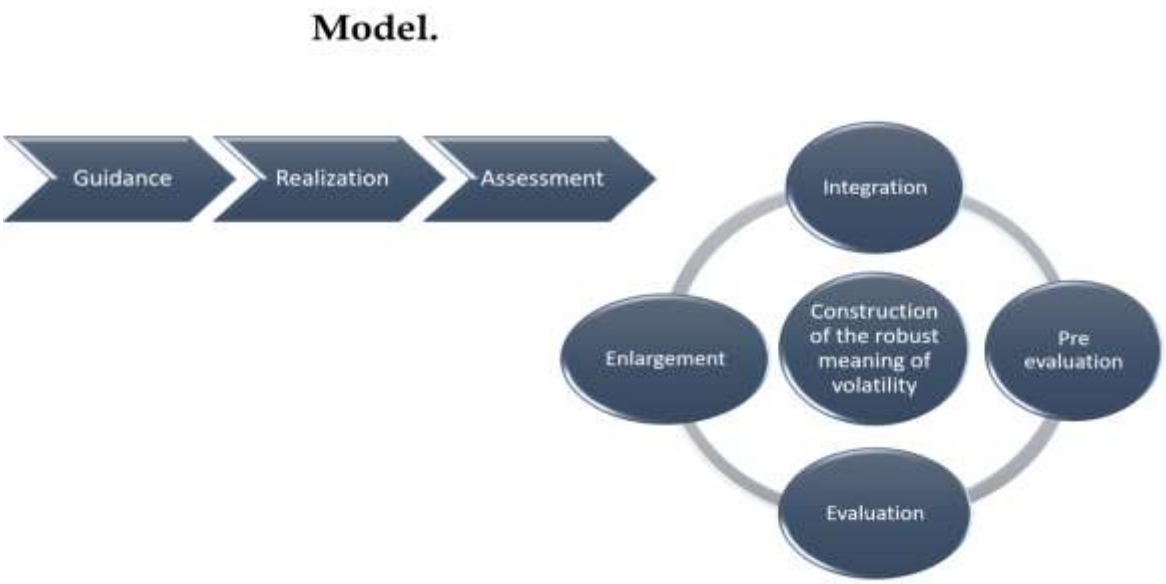


Illustration 2: Didactic model Used. Source: Díaz, Miguel. (2020) P. 33.

The didactic proposal concretizes the ideas embodied in the model, in order to make the general objectives of the model available to students. The didactic proposal shows the outline of the detailed work plan at each of the stages of the research and its summary.

Phase 1: Overview

In this phase, we made a tour through the concepts of statistics 1. Statistics 1 at the Antonio Nariño University are taught the concepts of descriptive statistics, counting and ends with the topic of probability and is deepened in the normal distribution. This phase consists of a review necessary for the student to have a good development of the sessions, as the student already knows part of these concepts, it is the task of the professor in charge to emphasize the financial applications and to detail the topics of the Log-normal and Brownian motion.The construction of the meaning of volatility will have its basis to the extent that the student understands sufficiently and in context, the topics to be taught in these 3 sessions, namely:

Activity 1: Previous concepts (Normal Distribution).

Activity 2: Log-normal distribution.

Activity 3: Simulation (Brownian Motion).

Phase 2: Actions

At this stage the student is expected to understand the meaning of the stock market from an academic, non-monetary or speculative point of view; clearly each action is a random variable that is given sufficient statistical treatment in order for its learning process to be absolutely contextualized, thus complying with the principles of Freudenthal's realistic mathematical education (1986), subsequent to this the student must be in the ability and suitability to meet the objectives of the Market Watch contest; this gamification in the statistical classroom is a magnificent scenario for the construction of the robust meaning of volatility in addition to have the possibility of applying simulations rich in probabilistic contents. Two sessions are planned as follows:

Activity 4. Actions I (Covariance)

Activity 5: Actions II (Regression and correlation)

Phase 3. Options valuation models.

In this phase the student already has enough knowledge to correctly apply with its own meaning of volatility to apply it easily to options valuation models, which will be very useful to form a strategic thinking in the student based on well-founded statistical decisions, to compare different investment plans regardless of their nature whether deterministic or stochastic. Two sessions are allocated for this phase;

Activity 6. Black Scholes model I.

Activity 7: Black Scholes model II.

The activities described above are carried out in the classroom as challenging problems without further theoretical information, in order for the student to gradually build their robust meaning of volatility by facing directly with the challenging problem, in this way, the apprentice must look for tools from his previous knowledge building, with the advice of the teacher, the generalization of the experience in the classroom.

On the other hand, an eighth activity was designed called: **"Challenge your creativity"** that takes place throughout the academic semester. This activity contains bigger problems that the student addresses partially and shows his progress as he builds his robust meaning of volatility in the classes.

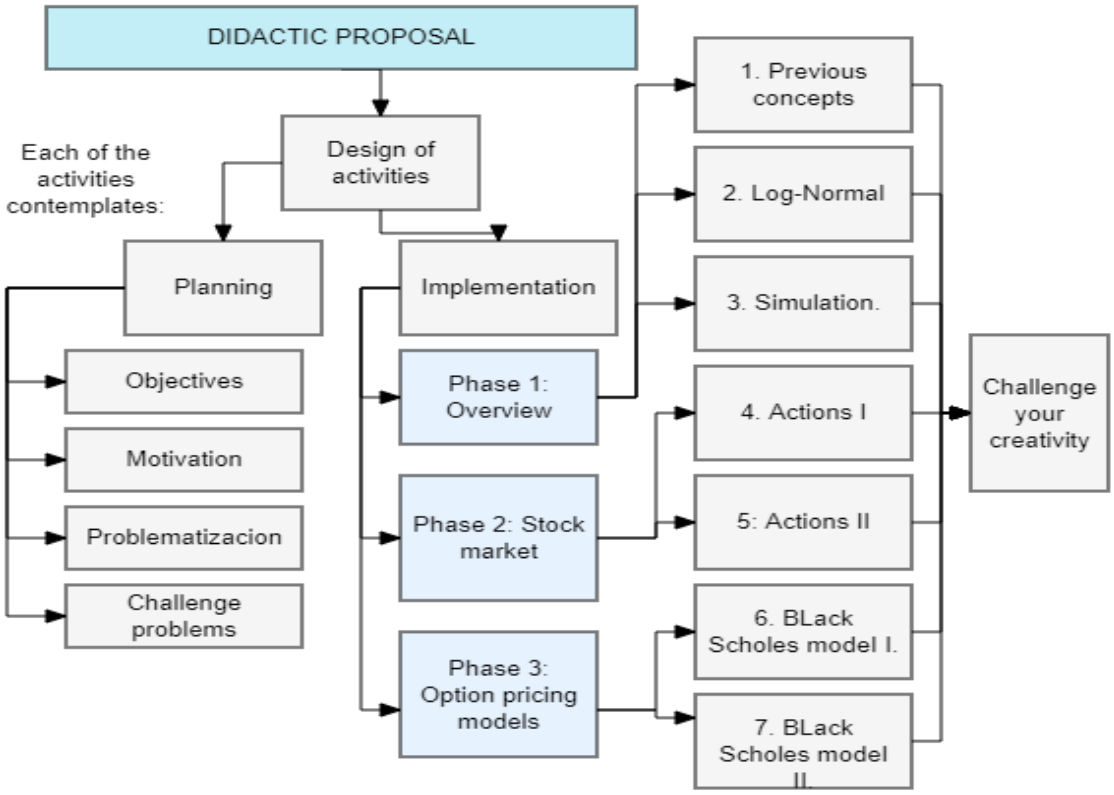


Illustration 2: General outline of the didactic proposal. Source: Díaz, M. (2020). P. 71.

Design of Activities

The form of the activities developed through problem solving is described below. Each of the activities has the same basic structure, both in format and in classroom development, seeking to correspond fully to the stages proposed in the didactic model, which in its practical part requires such activities, Therefore, the methodology must be designed using challenging problems proposed in an original way and that come to

create conceptual networks that encourage the construction of the robust meaning of volatility in each student.

The activities are proposed by sessions, in other words, each day corresponds to a specific activity and each day should be relevant when the intervention take into account the curriculum of statistics II of the Antonio Nariño University, in this way, detailed planning of each of the sessions is necessary in order to establish the exact moments of intervention so as not to affect the normal course of the subject,

Design of each session.

This section shows how each of the activities or sessions that allow the construction of the robust meaning of volatility is implemented. Each intervention has the following stages in its elaboration:

Planning

The topics to be taught, objectives, motivation and the proposed challenges are planned in detail. This phase is exclusively the responsibility of the teacher.

As a first step, an entry test was designed on volatility issues, in addition to activities for the eight sessions and the exit test. It is important that when this methodology is applied, the precise moments to apply each activity are taken into account so that the content of the syllabus does not see the need to delete topics, the purpose is to enrich, not replace topics.

Implementation

Once the activities are designed, house session is done with the same methodology, the introduction to the topic is made with current economic questions that may affect the outcome of the game, questions from the previous session, doubts in the autonomous work in the game Market Watch etc. It is important that the student finds significance in the theory and relates it to the daily life for this reason it is necessary to know his previous conceptions about the volatility. The presentation of practical situations investigates how they would model or provide a solution to some situation that occurs in the game or to economic conditions that affect it. A brief explanation of the problematization of the theory to be imparted is also made, it is to clarify that this theoretical exposition depends to a large extent on the topic of the session, a master class should not be made; the student is provided with the necessary conceptual tool for having a starting point. They may have some mistakes, but it is considered that the best way for them to build the meaning is from their mistake,*"... the participation of the student is active and there is no better way to build some own knowledge than from the very basis of his mistake"*Díaz (2020)P.36, for this reason the intervention of the teacher is marginalized to solve doubts in a guiding way, leading the student to his own generalizations in the measure of the effort and work against the proposed problems; without granting the concepts in their final form, this job corresponds to the apprentice, this is a construction of meaning. To the extent that concepts that are not strictly volatility arise, it will make that construction of meaning robust[5]. After that a brief explanation of the challenge problem is made, the student is oriented in the results to be hand over or shown at the end of the session and finally an accompaniment and orientation must be made in order to clarify doubts while the students program their spreadsheets, regarding concepts in statistics and dealing with obstacles with the software.

III. RESULTS

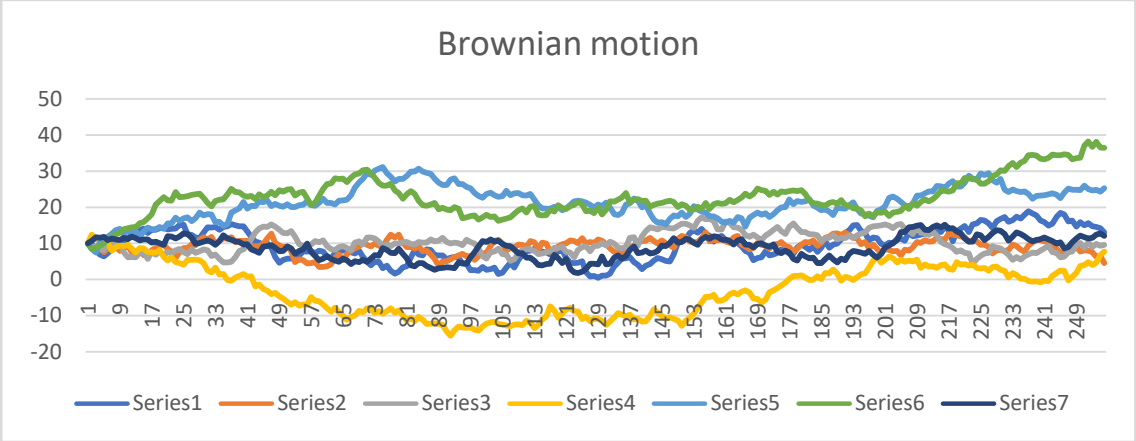
Below are some proposed problems; all of them can be found in Diaz, Miguel (2020)P.172.

[5]Pérez, D. (2016). Construcción de significado robusto para el concepto de área y caracterización del pensamiento geométrico involucrado en los estudiantes de sexto grado. (Tesis Doctoral). Universidad Antonio Nariño, Bogotá. P. 11.

Proposed challenge problems:

1. The chart below is a simulation of the price of a share with an initial value of $10 and *253 trading days.*

a. After analyzing the graph, what can be said about the simulation in series 4?



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b. Are random walks geometric or arithmetic? Justifyyouranswers.

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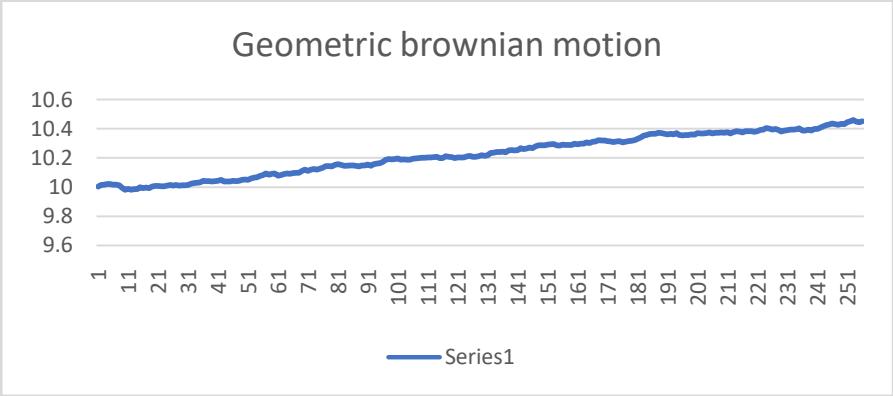
2. The graph below shows a 253-day simulation of an action with an initial value of $10.



Do you consider that the bullish trend is only due to the "good luck" of the values taken by the random component in the simulations? Justify numerically your answers.

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3. What relationship is there between $\mu y \sigma^2$ and the growth or decrease of S(t).

a. Simulate S(t) for the following parameter values with a t differential of $\frac{1}{256}$ *and observe the behavior of S(t) relative to S(0).*

b. Using the spreadsheet, count in each simulation the number of times that the amount $(\mu - \sigma^2/2)\Delta t + \sigma\sqrt{\Delta t}Z$ *it is positive or negative, for the following three cases:*

- ***i.*** $\mu = 0.1\%\ y\ \sigma = 10\%$
- ***ii.*** $\mu = 6\%\ y\ \sigma = 10\%$
- ***iii.*** $\mu = 1\%\ y\ \sigma = 40\%$

What is meant by the proportion of negative values in each case?

4. If you had to compare 2 assets knowing their average return and volatility, what criteria would you use? Tip: Look at Random Variables

$$X = ((\mu - \sigma^2/2)\Delta t + \sigma\sqrt{\Delta t}\, Z$$

Compared to the results, different ways of measuring the robust construction of meaning in the students were performed, grouped as follows:

1. Input and output tests on the subject of statistical volatility that are contrasted at the end of the academic period, these tests are analyzed using the Wilcoxon test (1970), after analyzing the nonnormality of the data obtained.
2. The results of two tests concerning the attitudes of students regarding the study of statistics and their usefulness are analyzed, using the instrument designed by Auzmendi (1992), in addition, an instrument is designed to measure students' attitudes to the subject of volatility specifically.
3. Each test is analyzed by means of the elements proposed by Godino (2002), regarding the elements present around the construction of meaning in the solutions handed over by the students.
4. Finally, the video material obtained by each of the sessions are analyzed using the methodology proposed by Planas (2006).

This way of measuring the construction of robust meaning is visualized in its entirety in Diaz, Miguel (2020)P.103, by the scope of this article is shown only the analysis of the perception of students on the subject of volatility.

Wilcoxon test "Sede Sur"

Student	Entrance	Output	Difference "D"	|D|	Sorted	Order range	Assigned ranges	Ranges of D
1	5,3	5,5	0,2	0,2	0,2	1	1	1
2	3,05	5	1,95	1,95	0,25	2	2	11
3	5,25	5,75	0,5	0,5	0,5	3	3,5	3,5
4	4,05	5	0,95	0,95	0,5	4	3,5	7
5	3,5	5,5	2	2	0,75	5	5,5	12
6	5,5	8,25	2,75	2,75	0,75	6	5,5	16
8	3,5	9	5,5	5,5	0,95	7	7	20
9	4,75	2,5	-2,25	2,25	1,25	8	8	13
10	4,5	7,25	2,75	2,75	1,5	9	9,5	16
11	5,75	6,5	0,75	0,75	1,5	10	9,5	5,5
12	5,5	4	-1,5	1,5	1,95	11	11	9,5
13	5,75	8,25	2,5	2,5	2	12	12	14
14	5,25	5,5	0,25	0,25	2,25	13	13	2
15	3,75	7,75	4	4	2,5	14	14	19
16	4	4,5	0,5	0,5	2,75	15	16	3,5
17	5,25	6	0,75	0,75	2,75	16	16	5,5
18	3,25	6	2,75	2,75	2,75	17	16	16
20	5,25	9	3,75	3,75	3,75	18	18	18
21	6,5	8	1,5	1,5	4	19	19	9,5
22	2,25	3,5	1,25	1,25	5,5	20	20	8

Qualitative variable:	Improvement in the proper conception of meanings related to the issue of volatility.
Qualitative variable:	Entrance and output tests

¿Is there a relationship between qualitative and quantitative variables?
Contrast of the comparison central trend

Sample size:	22	
T(+)=	187,5	
T(-)=	22,5	
Wilcoxon t-Value	22,5	
Level of significance	0,05	Two-tailed.
Critical t-value	66	

Ho: "The application of the teaching model does not affect the performance of students in topics related to the subject of volatility".
H1: "The application of the teaching model affects the performance of students in topics related to volatility".

Statistician test: Is outside the range (59,66) indicating that it should be accepted H1.

Figure 3: Analysis of results regarding the instrument related to the perception of volatility group 1, using the Wilcoxon test. Source: Díaz, Miguel. (2020) P. 193.

Test de Wilcoxon "Sede Federman"

Student	Entrance	Output	ifference "D'	|D|	Sorted	Order range	Assigned ranges
1	13,1	6,5	-6,6	6,6	0,1	1	1
2	9,7	5,5	-4,2	4,2	0,2	2	2
4	14,85	6	-8,85	8,85	0,55	3	3
5	18,35	5,5	-12,85	12,85	1,15	4	4
6	26,3	7,8	-18,5	18,5	1,2	5	5
7	31,05	9,8	-21,25	21,25	1,35	6	6
8	27,25	6,3	-20,95	20,95	1,85	7	7
9	28,8	6,8	-22	22	2	8	8
10	27,95	7,3	-20,65	20,65	2,25	9	9
11	29,95	6,3	-23,65	23,65	2,55	10	10
12	33,4	5,5	-27,9	27,9	3	11	11,5
13	39,3	6,8	-32,5	32,5	3	12	11,5
14	43	6,8	-36,2	36,2	3,2	13	13
15	47,4	9,5	-37,9	37,9	3,5	14	14
16	52,95	9	-43,95	43,95	3,65	15	15
17	41,45	5,5	-35,95	35,95	3,95	16	16
18	48,15	3	-45,15	45,15	5,15	17	17

Qualitative variable:	Improvement in the proper conception of meanings related to the issue of volatility.	
Qualitative variable:	Entrance and output tests	
¿Is there a relationship between qualitative and quantitative variables?		
Contrast of the comparison central trend		
Sample size:	17	
T(+)=	135	
T(-)=	18	
Wilcoxon t-Value	18	
Level of significance	0,05	Two-tailed.
Critical t-value	35	

Ho: "The application of the teaching model does not affect the performance of students in topics related to the subject of volatility".
H1: "The application of the teaching model affects the performance of students in topics related to volatility".

Statistician test: Is outside the range (30,35) indicating that it should be accepted H1.

Figure 4: Analysis of results regarding the instrument related to the perception of volatility, group 2. by Wilcoxon test. Source: Díaz, Miguel. (2020) P. 193.193.

IV. CONCLUSIONS AND RECOMMENDATIONS

It is identified that the use of technology in its teaching is no longer a trend, it is a necessity. The incorporation of the computer in the classroom for undergraduate students is not a novelty, it is part of its nature; teachers must adapt to these new social and pedagogical trends.

The concepts dealt with in the statistical classroom must be related to the daily life of the future professional. For this purpose teachers who teach such subjects must know and go a step beyond the old class structure of the behavioral school of form: "Axiom, Theorem, Demonstration and Example"; in order to go further, it must be involved in a way close to the student and his conceptions, in this way it can be oriented from his beliefs; for that reason the constructed meanings will be significant.

Problems in real contexts are critical for learning to correlate statistical concepts with their professional lives, as it is expected to be significant. In addition, this research shows that simulation in the classroom, particularly for statistics, should be a vehicle to deepen and accelerate the learning teaching process, this is facilitated today with the databases that abound and allows for better preparation of future professionals.

With the research a change in the attitude of students towards statistics is achieved particularly in the subject of volatility, this is evident in the analysis of the perception and satisfaction survey, it shows the

importance they give to statistics and the change in the face of their beliefs about the subject at the beginning of the academic period.

This new vision of the student in relation to statistics is absolutely consistent with the theoretical framework of research where the effect of gamification in the classroom, realistic mathematics and problem solving is positively related; faced with a negative attitude at the beginning of the course.

The research was able to demonstrate that the application of the didactic proposal presents a robust construction of the meaning of volatility that generates positive changes towards statistics and their application in finance.

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