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Logical Reasoning and Teaching Mathematical Statistics

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ABSTRACT---*The article addresses general knowledge about constructivism, significant knowledge, metacognition and logical reasoning, which constitute the theoretical basis for the methodological development of an alternative teaching-learning process for Mathematical Statistics, in a meaningful and coherent way. To do this, it starts with elementary contents of Arithmetic and Geometry, as a representation on the number line and Pythagorean Theorem to induce the formulas of central tendency and dispersion measures and provide the student with tools for understanding the contents. This proposal helps the student to learn more easily, not only Mathematical Statistics, but also provides a method based on logical reasoning, where the cause-effect relationship is evidenced, from the simple to the complex, and the verification of the main phenomena, which is useful for coping with cognitive tasks in broader fields.*

Keywords---*central tendency, constructivism, dispersion, knowledge mathematical, metacognition,*

I. INTRODUCTION

Human existence, in general, constitutes a constant decision-making process, and these are supported, whether we are aware of it or not, in statistical knowledge of reality. When deciding whether to use the services of a particular provider, for example, at different dates of the year or at different times of the day, it may be analyzed, among other factors, the demand over time of said services and that the concentration of customers can influence efficient management of available time and therefore affect our proper performance. In multiple spheres of life, data is collected, which are processed and analyzed to make informed decisions for the improvement of a specific situation, or the satisfaction of society's needs. Statistics is decisive in aspects such as scientific research, the administration of economic resources, the creation of public policies and the efficient administration of the state apparatus of nations, just to mention a few examples. However, despite the increasingly important role of Statistics, the teaching-learning methods of this science do not generally achieve the training of professionals capable of analyzing and interpreting data and obtaining all the necessary information from them. For an efficient decision-making process, mechanical or memorial learning is fundamentally based, formulas with no meaning for the student are memorized and work procedures are reproduced for the calculation of statisticians who represent nothing in the disciple's cognitive structure. Very little can creatively contribute who fails to penetrate the deepest essence of the phenomena until they become well-structured elements of their own knowledge system.

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A radical shift in the teaching of Statistics is defining, through methods that stimulate the development of logical reasoning and the construction of meanings that harmonize harmoniously with the knowledge structure, not in an isolated and arbitrary manner. These methods must be based on the most advanced pedagogical theories, that give students the leading role in their training and that banish teaching procedures that have been handed down from generation to generation, not precisely because of their effectiveness and, which are the cause of the situation described above. The general objective of the present work is to contribute to the development of a teaching-learning process of Mathematical Statistics where logical reasoning is the main tool in the construction of knowledge and, at the same time that new content is learned, it rises to a level superior students' intellectual capacity to unravel phenomena and penetrate their essence, that is, learn to reason logically. Learn content by reasoning logically to develop logical reasoning.

The theory of meaningful learning is developed by Ausubel, who is a follower of Piaget's constructivist theory of knowledge, so it is necessary to stop to analyze its main postulates. Piaget tries to explain throughout his work the problem of the origin of knowledge and its evolution: “to respond to this problem it is necessary to refer to how knowledge appears and transforms throughout development until it reaches its own forms of the adult” (Piaget, 1970). Piaget gives a fundamental role to the action in this process of origin and development, to know the objects the subject has to act on them, from this point of view the action is the foundation of all intellectual activity, from the simplest to the most complex. “For Piaget, knowledge is linked to action, to operations; that is, to the transformations that the subject makes on the world around him” (Delval, 1996). “The knowledge does not lie either in the object or in the subject separately, but it appears as a result of the interaction between the two” (Flavel, 1977); that is, that the intellectuality is the product of a gradual adjustment between the subject and its environment, through dynamic exchange, where the subject constructs and reconstructs the intellectual structures that allow him to understand reality more and more precisely. “According to Piaget, the object is known through successive approximations and requires elaboration by the subject” (Flavel, 1977), so that knowledge is not the mere incorporation of facts and phenomena through the organs of the senses, but a complex construction, where the subject creates, organizes, reorganizes and enriches his cognitive structures.

"Piaget also distinguishes in the knowledge, the complementary processes of assimilation and accommodation" (Flavell, 1977). “Assimilation is the integration of external elements into evolving or already finished intellectual structures” (Flavell, 1977), in other words, the subject goes to the world with already built knowledge, uses them to attribute meaning, to understand the surrounding reality and incorporate the compression on that reality into the previous structures of knowledge. However, assimilation does not guarantee the variations in knowledge structures alone, it needs another process that allows for the change and optimization of mental structures, this is that of accommodation. It is understood by this, to the modification that to a lesser or greater degree occurs in cognitive structures, when they are used to give meaning to new objects and areas of reality. "According to Piaget, objects offer some resistance to being assimilated by intellectual structures already built, so the subject must accommodate their structures so that they can also understand new objects" (Flavell, 1977).

There must be a balance between assimilation and accommodation, there is no accommodation without assimilation, nor assimilation without accommodation; the subject starts from a previous assimilating structure and every time he assimilates something, changes in the initial structure occur, but these accommodations are made within certain limits, governed by the need to keep the initial assimilating structure to some extent. Based on the previous postulates, Ausubel's theory of meaningful learning offers an appropriate framework for the development of educational work, as it states that learning depends on the previous structure that relates to new information, and is defined as such cognitive structure to the set of concepts and ideas that the individual possesses in a certain field of knowledge, as well as their organization. In the teaching process it is vitally important that the student knows the cognitive structure of the student, it is not only about the amount of information he has, but what are the concepts and propositions that he handles, as well as his degree of stability, and You should always consider that the educational work does not develop with blank minds, that the students' learning does not start from scratch, but that the students have experiences that can affect their learning or be exploited to enhance it (Diéguez, 2019).

"An apprenticeship is significant when the contents are related in a non-arbitrary and substantial way (not to the letter) with what the student already knows" (Ausubel, 1983). That is, that ideas and new information find a close link with existing knowledge in the cognitive structure of the student, such as an image, an already significant symbol, a concept or a proposition and somehow restructure the previous intellectuality. This reflects the importance of considering what the individual already knows to establish the relationship with what he must learn, in this way the student sees knowledge as the great system that is, without isolated or unrelated elements, that serve very little in the solution of real problems or as starting points for the assimilation of new knowledge, and what is more important, they serve almost nothing in the development of strategies that make it possible to optimally realize their learning, not only of a certain subject, but his learning in all areas of life (Diéguez, 2019). Regarding significant knowledge (Ausubel, 1983) states:

Meaningful learning occurs when new information is linked to relevant knowledge that already exists in the cognitive structure, new ideas, concepts and propositions are learned significantly only when other ideas, relevant concepts or propositions are adequately clear and harmoniously incorporated into the cognitive structure of the individual so that they act as the basis and foundation of the new content to be learned.

The most important characteristic of meaningful learning is that it produces a dynamic and developmental interaction between the most relevant knowledge of the initial cognitive structure and the new knowledge, so that they acquire meaning and are integrated into the cognitive structure in a non-arbitrary manner. , in this way they favor the differentiation, evolution and stability of the pre-existing subunsores and consequently of the entire cognitive structure (Ausubel, 1983). In contrast, "mechanical learning occurs when there are no adequate sub-sensors, so that new information is stored arbitrarily, without interacting with pre-existing knowledge" (Ausubel, 1983), in this type of learning the Information is stored in the form of islands, completely disconnected from one another's contents, and it usually happens that it is easily forgotten, since its period of permanence in memory is usually short, since the student cannot use some knowledge to reach others, The essence of phenomena is never reached, the student is only able to reproduce such information and can almost never use it creatively to solve problems or generate new knowledge (Diéguez, 2019).

II. Learning and logical reasoning.

Thinking is a complex act, which requires a set of mental operations such as: identification, ordering, analysis, synthesis, generalization, abstraction, comparison, classification, coding, decoding and establishing links, among others, when all these operations are harmoniously integrated and enable man from certain premises to arrive at logically grounded conclusions, a new intellectual quality, logical reasoning, appears. Reasoning is the mental activity that allows for the structuring and organization of ideas to reach a conclusion. Logic, on the other hand, is the science dedicated to the exposition of the forms, methods and principles of scientific knowledge. Something logical, in this sense, is that which respects these rules and whose consequences are justified, valid or natural (Pérez, 2015). Logical reasoning, in short, is a mental process that involves the application of logic. From this kind of reasoning, one or several premises can be started to arrive at a conclusion that can be determined as true, false or possible (Pérez, 2015). This can occur through observations, experience or hypothesis, can be inductive or deductive and is the organic link between premises and conclusions.

From the point of view of the teaching-learning process, logical reasoning allows establishing the relationships between the meanings present in the student's cognitive structure and the new contents to be incorporated, it is important that the teaching-learning methods used be based on this conception, because at the same time that it helps to learn significantly, it enables the emergence and development of a higher cognitive structure, with metacognitive abilities. Teachers usually complain about the students' lack of logical reasoning capacity, they cannot have a high degree of development of this capacity who has been instructed mostly with reproductive and mechanical teaching methods, logical reasoning is trained, developed and In this, the teacher has a decisive role as the main mediator of the teaching-learning process. The human organism is an open system that in its evolution acquired the propensity to modify itself, as long as there is a mediating human act (Feuerstein, 1972). At the heart of the Structural Cognitive Modifiability (MCE) is the theory of the Mediated Learning Experience (EAM), to which we attribute "human modifiability." EAM is a typical characteristic of human interaction, responsible for that unique feature of people that is "structural modifiability" (Feuerstein, 1972). The logical reasoning can be developed, only the favorable mediating human act is necessary in which the activity of the teacher must become, there may be people genetically disposed with a high development of this capacity, but any human being with normal intellectual index, can increase his reasoning logical if you find the right environment.

It is so much that pedagogues and psychologists, currently not only discuss how the process of knowing happens, but also about cognitive skills and tools. To measures that are learned, not only specific contents of a certain subject must be learned, it is necessary that cognitive skills and strategies are developed, that is, learning to learn, this is closely related to the term metacognition. "Metacognition is one of the areas of research that has most contributed to the configuration of new conceptions of learning and instruction" (Glaser, 1994). In (Osses, 2008), to measures that constructivism has gained an increasingly important place among the conceptions of learning, the role attributed to the conscience of the subject and to the regulation that he himself exercises of his own learning has increased. Metacognition, on the one hand, refers to "... the knowledge that one has about one's own cognitive processes and products or any other matter related to them and, on the other, to the active supervision and consequent regulation and organization of these processes" (Flavell, 1976). Thus, for example, metacognition is practiced when one becomes aware of the greater difficulty in learning one subject than another; when it is inviolable principle the non-acceptance of dogmas and it is understood that a phenomenon must be verified before accepting it as a science; when one thinks that it is necessary to examine each and every one of the alternatives in a multiple choice before deciding which one is the best, when it is warned that something should be noted because it can be forgotten.

Roa (2016), states that "… metacognition refers to the knowledge, awareness and control of one's cognitive processes during the act of learning by the student" (Carretero, 2001). He explains "... metacognition as the knowledge that people build about their own cognitive functioning." An example of this type of knowledge would be to know that, the organization of information in a scheme favors its subsequent recovery. On the other hand, it relates the metacognition to cognitive operations related to the processes of supervision and regulation that people exert on their own cognitive activity when faced with a cognitive task. The previous theories and pedagogical conceptions allow us to affirm that logical thinking can be cultivated and developed, which depends a lot on a harmonic and systemic cognitive structure that allows the student to construct the meanings of the new contents on the basis of the existing ones, which enable the accommodation and restructuring in an efficient way, but the mediating experience is defining, teaching methods should encourage students to learn to reason, all the reproductive and mechanical methods of the teaching-learning process must be banished. The teaching of Mathematical Statistics is full of expository methods, where the student behaves like a simple spectator that reproduces formulas and calculation procedures that mean nothing to him, from which they cannot obtain any conclusions, so in the following section It aims to show an alternative for the achievement of significant learning of the main sample statisticians studied in this subject.

III. SIGNIFICANT CONSTRUCTION OF THE CENTRAL TENDENCY AND DISPERSION SAMPLE MEASURES

According to UNESCO (1997) the teaching of Statistics is essential for the citizen by favoring the acquisition of knowledge and skills that allow them to access the information society. In this sense (Holmes, 1980) states the statistics play a fundamental role for the exercise of citizenship in an increasingly globalized world, because the modern subject is demanded to possess skills to read and interpret tables and graphs that are presented in the media for decision making. One must also be able to understand that information that is summarized by numerical indicators or graphic representations (Behar Ojeda, 2000). The foregoing becomes more relevant, when it aspires to the development of complex communication and expert thinking in citizenship (Reich, 2011). In this sense, it should be noted that for (Moore, 1991) statistics is the science of data and points out that its purpose is the reasoning based on empirical data, attaches great importance to the context, being the distribution of them one of the essential characteristics in the statistical analysis that tries to predict properties of a data set and not of isolated data (Bakker & Gravemeijer, 2004). For this reason, the teaching of statistics aims for students to develop the skills of reading, analyzing, criticizing and making inferences from data distributions (Shaughnessy, 2007).

Traditionally the teaching of Mathematical Statistics is based on expository and memorial methods with long, tedious and decontextualized procedures for the calculation of statisticians; If you consider the current development of Information Technology and Communications and the existence of software that automatically performs all the work of calculating these statisticians, the effort should now focus on the correct interpretation of results, it is not that students do not perform these procedures, but in a minimal way, to properly interpret the data you have to penetrate the deep essence of its meaning, learn them significantly.

The study of Mathematical Statistics begins with the introduction of measures of central tendency, essential for the theory and practice of Statistics and its compression is defining in the student's progress in learning this science, especially the arithmetic mean constitutes the based on the assimilation of more advanced knowledge, it allows to build and compare the different distributions of data, other concepts such as variance, standard deviation and average deviation are constructed through the arithmetic mean. In statistical inference, the sample arithmetic mean is a widely used estimator of the population mean since it has many of the desired properties for any estimator, which is why an adequate interpretation and understanding is important. An adequate way for the methodological treatment of this content can be through exercises where the mean of a data set is determined, its representation is made on the number line and the analytical interpretation of the mean is highlighted as an equitable distribution of the magnitude They represent the data.

Example:

Determine the arithmetic mean, median and mode of the following data set, represent the data on the number line and interpret the position of the mean with respect to the data set.

a) {17; 13; 14; 15; 16; fifteen; 15}

Solution.

$$\underline{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (1)$$

Where.

$\underline{x}$ → Arithmetic mean of the set.

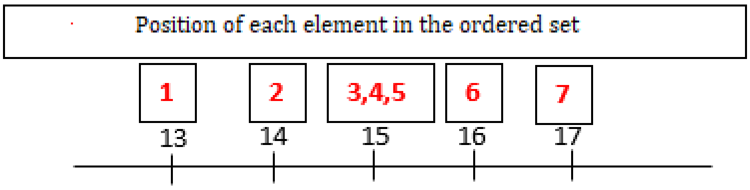
x_i→ Element "i" of the set i = 1, 2,…, n.

n→ Sample size

$$\underline{x} = \frac{17 + 13 + 14 + 15 + 16 + 15 + 15}{7} = 15$$

To determine the median, the student must be highlighted that a numerical value is being sought, which may or may not belong to the set of data, from which, both to the left and to the right of it, is the same amount of elements of the set, therefore, it is necessary to order it. The data set is sorted. {13; 14; fifteen;15; 15; 16; 17} Therefore, the median is the fourth element in the ordered set (15), because to the left of the mentioned element, there are the same number of elements of the set as to its right, three (3). Regarding fashion, its introduction is related to real life, asking the student. What does it mean that a certain item of clothing is fashionable? Among the possible answers of the students it appears that it is what is most used, that is, what is used most frequently, for example, that every ten (10) women four (4) wear jeans, three (3) wear zayas and three (3) wear dresses, it can be emphasized that fashion is wearing jean because when comparing garment to garment, jeans have a higher frequency than the other two, it is very important to highlight that this comparison is one to one, because there is a tendency To affirm that a value is the fashion of a set because it is a majority and this is incorrect, in the previous example most women do not wear jeans, this helps to introduce the concept of absolute frequency. In the previous set, the element with the highest frequency is 15, therefore, it is the fashion of said set.

Representation on the number line.



In this example, the central tendency measures coincide, examples must be presented where they do not coincide, to analyze the behavior of these statisticians, just as the exercises to be solved are not only reproductive, where the student only applies the formula and determines values that nothing means for him, exercises where these values are to be interpreted or that do not ask directly through the name of the statisticians, in addition to presenting situations where measures of central tendency are not representative of the data set and the student has to decide which of they are appropriate in the description of said set.

Example:

The daily dollar earnings of a group of friends are shown below.

{100; 75; 80; 75; 60; 90; 75; 109, 15000}

a) If the friends decided that everyone should earn the same, how much does each correspond?
b) Say the daily income that occurs most frequently.
c) Determine a numerical value that divides the set into two equal sets in terms of the number of observations (two sets with the same cardinal).
d) Relate which statistician has been used to solve each subsection, represents the set and the central tendency measures calculated on the number line, say whether or not these measurements belong to the set of observations.
e) Tell which of the trend measures offers a better description of the set. Argue your answer.

This methodological treatment, aims to provide the student with an image that makes it possible to build new knowledge on the basis of knowledge that they have already incorporated into their cognitive structure, also enhances the interaction between the object of knowledge and the subject of knowledge and the role of the action, the subject learns transforming reality, in this way the new knowledge is integrated into the cognitive structure of the student in a harmonious way and enrich it. The measures of central tendency are widely used in economic and social analyzes, it is common to find in the press reports where, for example, the average income or gross domestic product per capita by inhabitants is spoken, results that can give a false illusion of prosperity and social welfare if they are only seen coldly without a deep analysis of the real situation, that is, the measures of central tendency if they are used in an isolated way far from helping to interpret reality can distort it, this can be presented through the following example

The annual income of a group of 5 people is: $ 1200; $ 3000; $ 1700; $ 40000000; $ 1750 If for the analysis, we only use the average of this set that is $ 8001530, I could think that it is in the presence of a group of people with a high economic level, however, it is not so because there is a big difference between the Individuals in terms of their income, this example helps to show flaws that the average has, I have introduced the measures of dispersion. The student is informed that the measures of dispersion are used to confront these shortcomings, the meaning of the word dispersion is discussed and examples of sets that are more or less dispersed are shown, that the dispersion is related to the concept of distance between points with respect to a specific reference point.

The student is induced to conclude that one way to measure the dispersion is to calculate the difference between the maximum and the minimum of the data set, this value is called the data set path; In the previous example, the route is $ 39998800.00, so the average is not representative. Although the path measures dispersion of the data set, it only deals with its extremes, so it is not a good way to measure it. The following problem situation arises. How to measure how scattered a set of numerical data is with respect to a reference point? Through questions and answers, the teacher should guide the student to determine that this reference point should be the arithmetic mean of the data set, or through exercises where they have to complete tables as shown in table 1.

Table 1: The sum of the deviations of each element of a numerical set with respect to its arithmetic mean is zero (0)

x_i	$x_i - \underline{x}$
5	0
3	-2
6	1
7	2
5	0
3	-2
2	-3
6	1
8	3

$\underline{x} = \frac{45}{9} = 5$ $\sum_{9}^{i=1} \quad xi - \underline{x} = 0$

Table 1, Students must complete the elements that are highlighted in red, the objective is to induce ownership: the sum of the differences between each of the elements of the set and the arithmetic mean of said set equals zero. You can build the table in Microsoft Excel for students change the values of the x_i (elements of the first column) and entire calculation is performed automatically, so students arrive at the conclusion that this property is fulfilled Regardless of the data set, this procedure offers students an experience that increases the interaction between the subject and the object of knowledge, in addition to an image, a mental representation for the construction of meanings based on what is already known. At this moment, this property is demonstrated $\sum_{n}^{i=1} \quad xi - \underline{x} = 0$, the student is informed that the evidence provided by the particular cases analyzed is not enough, that the demonstration must be carried out.

$\sum_{n}^{i=1} \quad xi - \underline{x} = (x_1 - \underline{x}) + (x_2 - \underline{x}) + \ldots + (x_n - \underline{x})$.

Applying the associative of the addition and reducing similar terms is obtained.

$= x_1 + x_2 + \cdots + x_n - n\underline{x})$, substituting $\underline{x}$ for, $\frac{x_1 + x_2 + \cdots + x_n}{n}$ The following expression results, $= x_1 + x_2 + \cdots + x_n - n\,(\frac{x_1 + x_2 + \cdots + x_n}{n})$, simplifying "n", you get $= (x_1 + x_2 + \cdots + x_n) - (x_1 + x_2 + \cdots + x_n) = 0$

When conducting this demonstration, students are told how, with the analysis of particular cases, we can arrive at conjectures or hypotheses, but it is not enough with them. It is necessary to demonstrate them so that they become science, that dogmas should not be accepted, that scientific statements must be supported by

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demonstrations that have their base or foundation in other scientific knowledge, in addition, the arithmetic mean begins to be highlighted as the appropriate reference point for Measure the dispersion of a set. The property that expresses the formula ∑_n ^ (i = 1) xi-x = 0, it is possible to relate it to the contents received in Physics as is the case of the displacement vector. In this way, contents of different subjects are related. Displacement is understood as the oriented vector or straight segment that joins the initial position with the final position of a certain path.

That is, se (d_x) ⃗ = xf - x0,

Where:

$\overrightarrow{d_x}$ → displacement of point "X".

xf → end position of point "X".

xo → initial position of point "X".

Therefore, the arithmetic mean of the set of numerical values "A", can be interpreted as, that numerical value x, which may or may not belong to said set, but that, if all values of the set had to be shifted, until coinciding with x, the sum of these displacements is equal to 0 (zero) and, this property makes it appropriate as a reference point for the calculation of the dispersion measures. Among the main properties of the arithmetic mean (Batanero, 2000), the sum of the deviations of the observations with respect to the average is zero. By means of the analytical interpretation of the previous property, the formula of the arithmetic mean can be deduced and not given directly, in this way, the logical reasoning is stimulated and the learning is significant, bone was previously based on the definition of arithmetic mean and the property ∑_n ^ (i = 1) xi-x = 0 is demonstrated, now it is part of the same property that must meet the value x, to deduce its formula and give the definition of it, it is interesting that both methods discuss in the classroom as problems to be solved by the students.

According to this property, ∑_n ^ (i = 1) xi-(x) = 0 must be met, which is the same.

(x_1-x) + (x_2-x) +… + (x_n-x) = 0, grouping and reducing similar terms, you get, x_1 + x_2 +… + x_n - n x = 0, adding n X to both members, it turns out

x_1 + x_2 +… + x_n = n x, if both members are divided by “n”, x = (x_1 + x_2 + ⋯ + x_n) / n.

According to (Sánchez, 2007) The arithmetic mean is defined as an average value such that, if each term is given that value, it is a sum equal to that of the values of the terms of the given sequence.

Algebraically, the above definition can be expressed as.

$\underline{x} + \underline{x} + \ldots. + \underline{x} = x_1 + x_2 + \cdots + x_n$

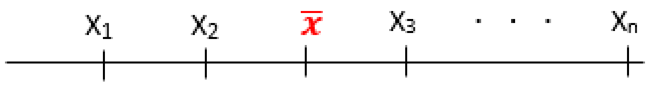
$n\underline{x} = x_1 + x_2 + \cdots + x_n$

$\underline{x} = \frac{x_1 + x_2 + \cdots + x_n}{n}$, in this way a content that is generally introduced mechanically and arbitrarily, is contextualized and its formula is deduced from its definition or from a certain desired characteristic.

Once the arithmetic mean has been determined as the reference point for measuring dispersion, now the problem is reduced to finding a way to calculate how scattered the elements of a set are with respect to their arithmetic mean.

The ∑_n ^ (i = 1) xi-x (2), (sum of the deviations of the elements of the set with respect to its arithmetic mean) is not appropriate because all sets of numerical values would have the same zero dispersion (0), this can be solved by entering the absolute value within the summation sign, as follows. ∑_n ^ (i = 1) | xi-x | (3), (Sum of the absolute values of the deviations of the elements of the set with respect to their arithmetic mean)

Let the set A = {x1; x2; ... xn} which has half x.



A measure that can indicate how scattered a set can be the sum of the distance of each element to the arithmetic mean of that set, as shown in (3), so the concept of distance between two real numbers “a” is used and "b" which is the absolute value of the difference between them. d (a, b) = | b - a | (4): Formula to determine distance between two real numbers on the number line.

Therefore, dispersion (A) = | x_1-x | + | x_2-x | +. … + | X_n-x |, but obviously, a measure of dispersion calculated in this way is affected by the cardinal of the set (n), to avoid this inconvenience it is necessary to divide the sum by “n”, so The above formula is transformed into.

Dispersion (A) = (| x_1-x | + | x_2-x | +.… + | X_n-x |) / n, this measure of dispersion is called the mean deviation and its formula can be summarized as shown in equation 5.

$$Dm = \frac{\sum_{i=1}^{n} |x_i - \bar{x}|}{n} \qquad (5)$$

Where:

Dm → Average deviation

N → Sample size.

It is very important that the average deviation be understood as another arithmetic mean, the arithmetic mean of the distances between each element “xi” and x. From this formula, the variance can be introduced as, the arithmetic mean of the squares of the distances between x and xi, is calculated with equation (6).

$$S^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1} \qquad (6)$$

Where:

S2 → the sample variance.

And the standard deviation as the square root of the variance is calculated with equation (7).

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} \qquad (7)$$

Where:

S→ Sample standard deviation.

The student should be told that the denominator changes by (n - 1) that, in the case of variance and the population standard deviation, the denominator is "N" (Population size). It is possible to make certain geometric constructions that facilitate the understanding of the meaning of dispersion measures. Let Set A = {x1; x2}, in this case, $\bar{x} = \frac{x_1 + x_2}{2}$, if a right triangle is constructed whose legs are equal to the distance between xi and x¯(isosceles right triangle, because in this case the arithmetic mean is the midpoint of the interval [x1; x2]. Shown in Figure 1.

d = |x_1-x⏉= |x_2-x⏉ (8)

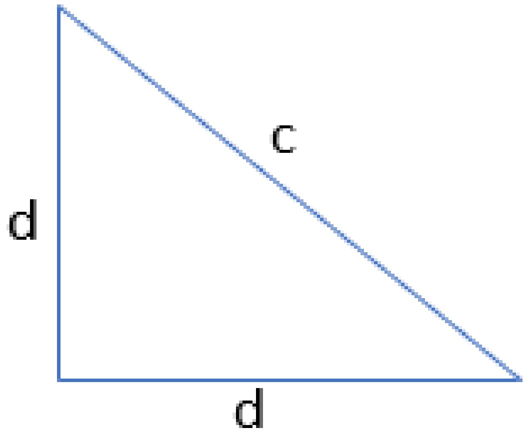


Figure 1: Right triangle for the analysis of the standard deviation of a set of cardinal two (2)

If the Pythagorean theorem is applied, c = √(d^2+ d^2) (9) is fulfilled, substituting (8) in (9), it is obtained, c = $\sqrt{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2}$), which coincides with the numerator of the standard deviation of the set "A", to determine it, just divide it by two (2).

In the case of a set of cardinal three (3), be the set A = {x1; x2; x3}, therefore $\bar{x} = \frac{x1 + x2 + x3}{3}$, let

a = $|x_1 - \bar{x}|$, b = $|x_2 - \bar{x}|$ y c = $|x_3 - \bar{x}|$.

We proceed to the construction of an orthohedron whose edges measure a, b and c (Figure 2).

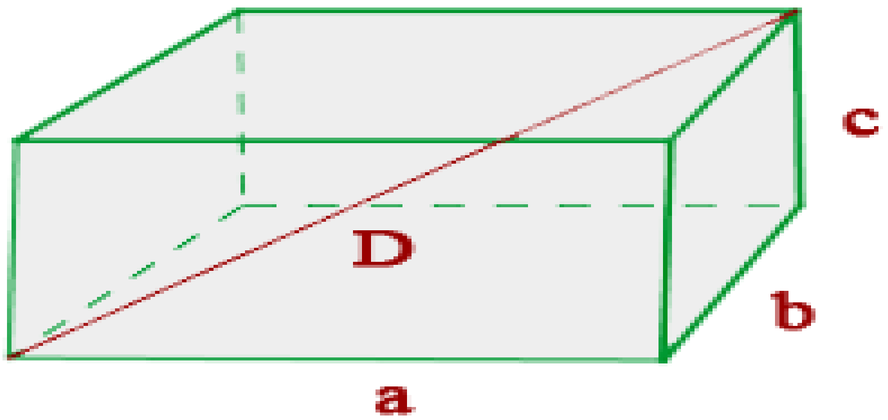


Figure 2: Orthopedic for the interpretation of the standard deviation in a set of cardinal three (3), taken from https://www.ditutor.com/geometria/diagonal_ortoedro.html

It is known that D = $\sqrt{a^2 + b^2 + c^2}$ (10): Formula for calculating the length of the main diagonal of an orthohedron.

Substituting a, b and c in (10) is obtained.

D = $\sqrt{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2}$,

Which also coincides with the numerator of the standard deviation of the set, to obtain it, you just have to divide it by three (3).

A similar analysis is fully feasible for the variance, of data sets with cardinal equal to two (2) or three (3), when the cardinal is greater, the problem leaves the three-dimensional space, but this type of geometric construction helps generalization and understanding of dispersion measures. When the cardinal of the data set is greater than three (3), analysis is carried out using a n-dimensional vector $\overrightarrow{d_n} = (d_{1\,,}\, d_{2\,,} \dots , d_{n\,,})$, where each $d_i = |x_{i\,-\,\bar{x}}|$, the standard deviation coincides with the nth part of the vector module, thereby reinforcing the notion of the standard deviation as a measure that integrates the distances between each element of the set and its arithmetic mean. This methodological treatment guarantees that contents that are traditionally introduced mechanically and arbitrarily, without links with previous knowledge in the cognitive structure of the students, are deduced, so they enable the development of logical thinking and the capacity for statistical analysis and interpretation , which is the fundamental part in the objectives of the subject, because all the part of the calculation of the statisticians, due to the development achieved by the computer science, is currently carried out by specialized software and the users must only perform their interpretation for this purpose The decision making. But it is a necessary condition to know the deepest essence of a phenomenon in order to understand and interpret it.

IV. CONCLUSION

1) The teaching of Mathematical Statistics based on meanings present in the student's cognitive structure, constructivism and metacognition, is of vital importance to provide students with tools that enable them to self-learning and constant self-improvement; However, for the teaching of this subject, no methodological proposals were found, based on logical reasoning, that systematically integrate these pedagogical theories, which ensure the development of a harmonious cognitive structure in the student.

2) The methodological proposal presented is based on the systemic integration of theories of meaningful knowledge, metacognition and constructivism, which manages not only to make the classes of Mathematical Statistics more attractive and dynamic, but also to contextualize them.

3) The treatment that is given in the present work to the teaching-learning process of the measures of central tendency and dispersion, is fully applicable in all levels of education where they are taught, since it starts from elementary preconditions, also feels the bases and shows the way, so that other contents or knowledge are constructed by similar procedures**.**

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