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Application of a methodological strategy for teaching general statistics to students in the third cycle of Sanitary Engineering with a view to raising the level of knowledge assimilation, semester 2023–I, UNASAM

[Aplicación de una estrategia metodológica para la enseñanza de la estadística general a estudiantes del tercer ciclo de Ingeniería Sanitaria con vistas a elevar el nivel de asimilación de conocimientos, semestre 2023-I, UNASAM]

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Resumen

El propósito de la investigación es determinar la influencia de la aplicación de una estrategia metodológica para elevar el nivel de asimilación del conocimiento de la estadística general en los estudiantes del III ciclo de Ingeniería Sanitaria, semestre 2023 – I, UNASAM - Huaraz. En la investigación se aplicó una estrategia metodológica que contribuye a hacer más efectivo el proceso de enseñanza – aprendizaje, elevando el nivel de asimilación del conocimiento; en este sentido, se encontró que el enfoque histórico-cultural de Vygotsky y la teoría de la actividad, proveen la base científica para elaborar un sistema didáctico con tales características, capaz de crear en el estudiante la necesidad de adquirir conocimientos, habilidades y desarrollar estrategias voluntarias y deliberadas de trabajo con los cuales se logró mejorar el aprendizaje de la estadística general y dentro de esta perspectiva mejorar la formación profesional. La investigación es tipo aplicada, método cuantitativo y diseño pre experimental; se aplicaron dos instrumentos: pre test y post test aplicados a una muestra de 21 estudiantes, para la contratación de la hipótesis se utilizó la prueba T-student para muestras relacionadas a un nivel de significancia del 5%. De los resultados se concluye que la aplicación de la estrategia metodológica enfoque histórico cultural y la teoría de la actividad influye significativamente para elevar el nivel de asimilación del conocimiento de la estadística general de los estudiantes del III ciclo de Ingeniería Sanitaria semestre 2023 – I.

Palabras clave: Enfoque histórico-cultural, teoría de la actividad, asimilación.

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Abstract

The purpose of this research is to determine the influence of applying a methodological strategy on improving the level of knowledge assimilation of general statistics among third-year Sanitary Engineering students, semester 2023-I, at UNASAM - Huaraz. The research applied a methodological strategy that contributes to a more effective teaching-learning process, raising the level of knowledge assimilation. In this regard, it was found that Vygotsky's sociocultural approach and activity theory provide the scientific basis for developing a didactic system with these characteristics, capable of creating in students the need to acquire knowledge and skills, and to develop voluntary and deliberate work strategies. This, in turn, improved the learning of general statistics and, from this perspective, enhanced professional training. The research is applied, quantitative, and pre-experimental in design. Two instruments were applied: a pre-test and a post-test, administered to a sample of 21 students. The paired-samples t-test was used to test the hypothesis at a significance level of 5%. The results indicate that the application of the historical-cultural approach and activity theory methodological strategy significantly influences the level of assimilation of general statistics knowledge among third-year Sanitary Engineering students in the 2023-I semester.

Keywords: Historical-cultural approach, activity theory, assimilation.

I. Introduction

We are witnessing a time of change and transformation driven primarily by the great advances in science and technology. To cope with this rapid progress in science, it is necessary to reflect on and propose a new teaching and learning process. Therefore, those who assume the responsibility of education must commit to educational innovations that help guide learning, fostering critical thinking and adapting to the realities of the context in which they work. This requires combining methods and strategies to achieve the new professional profile that society currently demands. Teachers must leverage students' prior learning and skills to achieve meaningful learning, thereby improving the training process and the performance of the new professional's duties.

At UNASAM, and specifically in my experience teaching general statistics, I have observed that the prevailing system among students is the traditional one, and the method used to impart the main knowledge is primarily lecture-based. This problem is exacerbated by my background as a statistician, not as a professional educator. For every professional, statistics is a tool they will use continuously, both in their student life and in professional practice. Therefore, it is essential to prioritize the transmission of information through the teaching of critical thinking, with the aim of perceiving problems, analyzing them, making complex judgments using statistics, and then making decisions, prioritizing reasoning methods over memorization. With the aim of contributing to improving the quality of education for all students, and within this perspective, improving the teaching of general statistics by applying a methodological strategy based on the historical-cultural approach and activity theory, a system of tasks was implemented for students based on selected content. This system utilized Galperin's (1995) teaching theory to raise the level of generalization and awareness of the content. In this context, the teaching process is studied by psychology and pedagogy. The first studies the laws of assimilation and the second is responsible for elaborating, on the basis of these laws, the principles of teaching that satisfy the demands of the theory of management; where it shows that the specific character of this process requires a cyclical management.

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According to Galperin (1995), the theory of the stage-by-stage formation of mental actions maintains that in every human action, there is a motive for performing the action and an objective for executing it. If the motive and objective coincide in an action, it is considered an activity. In the case of learning, it is more efficient if the student learns to satisfy cognitive needs, and if these objectives also benefit society. Another component of action is operations; their sequential execution forms the process of action completion, which is divided into three parts: orientation, execution, and control. The organization of the assimilation process must take into account the three functional components of every activity: the orientation, execution, and control phases. To organize the assimilation process, the objectives must first be reformulated in terms of skills or developed in the student related to professional tasks. The content must follow the logic of the science being studied, which constitutes the subject's knowledge, and to teach this knowledge, logical skills or strategies must be used. Therefore, a specific system of logical strategies must be included in the teaching content. This will allow the results obtained to prove the effectiveness of the proposed methodological strategy for teaching general statistics.

Based on the above, the following research problem is posed: How does the application of a methodological strategy influence the level of assimilation of general statistics knowledge in third-year Sanitary Engineering students, semester 2023-I, UNASAM?

To provide a tentative answer to our research problem, the following research hypothesis was considered: The methodological strategy significantly influences the level of knowledge assimilation in third-year Sanitary Engineering students, semester 2023-I, UNASAM; this will be verified through hypothesis testing. Regarding the research topic, there are some related studies (correlational and quasi-experimental) that are relevant to this work, specifically studies on Maple V. 18 software and learning in Mathematics II, which were necessarily taken into account in this research.

Haro (2020), in her doctoral thesis “Working with the Zone of Proximal Development in the Teaching-Learning Process” – Spain, argues that the application of the developmental teaching-learning process from a historical-cultural perspective in schools allows for the development of skills and strategies that foster learning and task completion; that actions mediated by the teacher or classmates stimulate the zone of proximal development (ZPD), facilitating the transition from lower to higher levels of knowledge. This teaching-learning process aligns with our research, achieving a holistic development of the individual through classroom activities that strengthen students' self-regulated and independent personalities, fostering more robust teamwork skills. Similarly, Solís and López (2020), in their research entitled “The Historical-Cultural Approach Applied to the Teaching of Mathematics with the Use of ICTs” – Cuba, state that writing this article has provided an opportunity to document what has become a daily practice in the teaching profession. Once the precepts of the historical-cultural approach, as well as the educational currents related to it, are understood, this type of teaching allows students to acquire skills such as observation, enabling them to describe, analyze, and explain different phenomena through their connections and relationships; thus facilitating a better understanding of objective reality. We can confirm that this type of teaching improves education in the way students learn.

Rodríguez (2020), in her research entitled “New Developments in the Historical-Cultural Approach: Its Relevance to Contemporary Education,” argues that the analysis of texts belonging to this revisionist movement documents how it has fostered critical reflection on some key Vygotskian concepts in the field of education, such as the zone of proximal development. She concludes that contemporary developments in the historical-cultural approach can contribute to an education that responds more effectively to the demands of the current historical, social, and cultural transformations that have been imposed upon it. Similarly, we consider the findings of Hernández and Cañedo (2018), in their research entitled “The Historical-Cultural Approach as a

GESj
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Strategy in the Training of Pedagogues at a Private University in San Luis Potosí, Mexico." They maintain that social learning based on Vygotsky's historical-cultural approach provides teachers with the possibility of generating, within their classrooms, the precise situations that foster collaborative learning through an active-transformative orientation for the acquisition of knowledge and real learning in students. The findings of Gutiérrez (2020), in his research entitled "Methodological Strategies of Teachers and Academic Performance in Students of the Professional Academic School of Education at the Faculty of Education of the National University of San Marcos," aimed to determine the relationship between teachers' methodological strategies and students' academic performance. It was concluded that the high academic performance of most students is related to the methodological strategies used by teachers during learning sessions, which include teaching methods, techniques, and resources, as well as the application of didactic materials. Similarly, Rojas (2020), in his research entitled "Application of a Basic Social Skills Program Based on Vygotsky's Theory," aimed to implement a social skills program to improve meaningful learning in students at technical-productive centers within the jurisdiction of the Sullana Local Education Management Unit (UGEL) in 2020. His research concluded that group dynamics help students become less inhibited and participate spontaneously, and that the application of these techniques and strategies leads to improved academic performance. These results, based on group dynamics, align with our research, demonstrating an increase in students' knowledge.

The organization of the classes for the selected topic

The objectives were revised in terms of tasks for the general statistics course. The classes were organized taking into account the structure of the content of the selected topic, the logic of the course, and establishing a relationship between the topic and the tasks that were completed. This allowed for the assimilation of the content at a reflective level. The skills outlined in the objectives were developed following the stages of assimilation of the theory (Galperin, 1995). Participatory teaching methods and techniques were used, which surpassed any form of knowledge assimilation. These methods were selected in such a way that they successfully organized student activity, allowing them to participate directly in solving tasks or problems related to the subject matter and appropriate to the stage of the assimilation process the students were going through. The learning process for each class was organized based on Galperín's (1995) stage-based theory of mental processes, which was as follows:

a) Motivation: Motivation for the selected topics was fostered through questions to introduce the student to the task, and through problem-solving by presenting a problem for each topic. This aimed to connect professional activity with the nature of the subject matter and, in other cases, with practical situations.

b) Guiding Basis for Action: To solve the problem or answer the questions posed in the motivational phase, the professor provided information on the essential basic content and the appropriate procedures for solving the problem. At this stage, printed materials on the topic's content or bibliographic information were provided to allow students to deepen their understanding.

c) Materialized Stage: In this stage, the student was given a set of exercises (homework), which they had to complete in the classroom, individually in some cases and in pairs in others, using the basic and essential knowledge and problem-solving procedures provided in the previous stage. The student also had the support of a study card containing definitions of basic concepts, procedures for solving the problems, and a checklist for completing the task. The student also adjusted and monitored their learning through observation and evaluation of the tasks.

d) Verbal Stage: When the tasks were completed in pairs or groups, verbalization was encouraged. The student explained or argued to their partner how they solved the problem, and the partner did the same. Subsequently, the student presented their solution to the class and was required to reflect on what they did and how they did it, using the essential elements of the subject matter, thus developing their reflective skills. The teacher guided the individual, pair, and group work.

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e) Mental Stage: In this stage, the teacher assigned students homework consisting of a set of exercises and problems, which they worked on individually and then presented in a plenary session. This plenary session was held one session before the Unit I exam, as a form of feedback. At the end of each class, the teacher recorded the students' levels of understanding and how the quality of their reflection was improving.

Selection and Use of Participatory Methods

The methods were chosen according to the tasks the student had to perform, the formulated objectives, the content, and the organization of the classes. When choosing the method, it was also considered that it allows for self-regulation of the activity and self-monitoring of the results, guaranteeing the active participation of students individually or in groups to foster not only the assimilation of knowledge but also the development of their personality.

Monitoring and Evaluation of Learning

The monitoring and evaluation of knowledge was carried out to identify students' difficulties, to motivate them, and to correct their errors through feedback; in this way, the process could be regulated or rectified at the appropriate time. The following instruments were used for the evaluation:

a) The pre-test. It was developed taking into account basic mathematical knowledge related to elementary algebra, summation, and data organization, developed in previous classes whose content is related to descriptive statistics and probability.

b) Evaluative tasks outside of class. To assess students' understanding of descriptive statistics and probability, they were presented with an exercise in which they had to calculate and interpret these descriptive measures. This exercise was used to evaluate their level of reflection on the topic.

c) The post-test. Evaluation was conducted during the execution of the written and verbal stages to measure the level of reflection achieved. Monitoring involved observing students' work based on their successful completion of tasks, their participation in plenary discussions, their reflections, their mastery of essential knowledge, and their application of knowledge to new situations. The mental stage was assessed by monitoring students' presentations of their out-of-class work during a class session. This test allowed us to measure statistical knowledge and skills at different levels of assimilation based on the students' reflections on the topics of descriptive measures and probability.

II. Materials and Methods

Type of research

Based on its approach, it is a quantitative study (Hernández and Mendoza, 2018). The quantitative approach is sequential and evidentiary, starting with an idea that is gradually narrowed down. Once delimited, research objectives and questions are derived, the literature is reviewed, and a theoretical framework or perspective is constructed.

Based on its utility, it is an applied research study (Carrasco, 2019). Applied research is distinguished by its well-defined, immediate practical purposes; that is, it investigates to act, transform, modify, or produce changes in a specific sector of reality. The purpose of this study is to implement a methodological strategy to improve the understanding of general statistics among third-year Sanitary Engineering students in the first semester of 2023.

Due to its depth, this is an explanatory study because it is based on representative samples from a specific population. This allows us to establish causal relationships that explain the object of study; in other words, we will observe or manipulate the external phenomenon (Hernández and

GESj
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Mendoza, 2018). The research is explanatory because it aims to explain how the application of a methodological strategy improves the understanding of general statistics among Sanitary Engineering students in the first semester of 2023 at UNASAM.

Research Design

Research design can be defined as a structured or organized framework adopted by the researcher to relate and control the study variables. Furthermore, the design serves as a guiding and constraining instrument for the researcher, becoming a set of guidelines under which the experiment or study will be conducted (Hernández and Mendoza, 2018, p. 126).

The research design will be pre-experimental because the methodological strategy will be applied to determine how the level of knowledge assimilation increases, using a single-group, pre- and post-test design model, following this scheme:

$$EG: O_1 ----------X----------O_2$$

Where:
EG: Experimental group (single)
CG: Control group
O1: Pre test
O2 : Pos test
X: Methodological Strategy

Population

In this research, the population considered was the 24 students enrolled in the General Statistics course during the 2023-I academic semester at the School of Sanitary Engineering – UNASAM.

Population Characteristics

Inclusion Criteria

- Students who attend all scheduled classes.
- Students who take all scheduled assessments.
- Students taking the course for the first time.

Exclusion Criteria

- Students who do not attend all scheduled classes.
- Students who do not take all scheduled assessments.
- Students taking the course two or more times.

Sample

The sample was selected using purposive non-probability sampling (Hernández and Mendoza, 2018). The sample consisted of the 21 students from the School of Sanitary Engineering during the 2023-I semester at UNASAM.

Instrument

Hernández and Mendoza (2018) maintain that the instrument is the physical or virtual means used to collect data. In this research, a questionnaire was used as the instrument. It contained simple questions that allowed for the collection of data to analyze knowledge assimilation among Sanitary Engineering students in the General Statistics course.

The following instruments were used:

Pre-test: This was administered at the beginning of each unit, consisting of a written test lasting approximately 70 minutes. This test allowed for the diagnosis and analysis of students' prior knowledge of the topic.

GESj
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Post-test: This was administered at the end of each unit, after the methodological strategy was implemented. The test was similar to the pre-test.

For the processing and statistical analysis of the data, statistical packages such as SPSS version 25.0 and Microsoft Excel 2016 were used. Likewise, to test the research hypotheses, the paired t-test was used with a 95% confidence level.

III. Results

This section presents the main results obtained during the research process. These are presented through tables and hypothesis tests, along with their descriptions and interpretations, based on the key research variables.

Presentation of Results

Table 1. Shapiro-Wilk Test to Establish Normality

	Statistics	n	p-value
Pre test I Unit	0,918	21	0,080
Post test I Unit	0,959	21	0,495
Pre test II Unit	0,926	21	0,113
Post test II Unit	0,942	21	0,235

Source: researcher's scores record

Table 1 shows that, according to the Shapiro-Wilk test, the p-value > 0.05 for the pre-test and post-test scores for descriptive statistics (Unit I) and probability (Unit II) follow a normal distribution.

Table 2. Average pre-test and post-test scores of third-year Sanitary Engineering students in the general statistics course, semester 2023-I

Units	Pre test		Post test	
	Average	Standard deviation	Average	Standard deviation
I Unit	5,80	1,07	11,46	2,75
II Unit	5,86	1,42	12,32	3,36

Table 2 shows that in Units I and II, the average score increased significantly from the pre-test to the post-test. These results confirm that knowledge assimilation in the general statistics course improved favorably.

Table 3. T-test of pre- and post-test scores for knowledge assimilation in the general statistics course for third-year Sanitary Engineering students, semester 2023-I

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	Standard Deviation	t	gl	p-value
Pre test I Unit Post test I Unit	2,378	-11,717	20	0,000
Pre test II Unit Post test II Unit	2,302	-12,865	20	0,000

Source: Researcher's notes.

Performing statistical analysis with the Student's t-test for related samples in Units I and II yielded a significant result ($p<0.05$), confirming that the application of the historical-cultural approach methodology and activity theory significantly influences the level of knowledge assimilation among third-year Sanitary Engineering students in the general statistics course.

Table 4. T-test of the pre- and post-test scores in the assimilation of knowledge in Descriptive Statistics of the students of the III cycle of Sanitary Engineering semester 2023 -I

	Average	Standard Deviation	t	gl	p-value
Pre test I Unit Post test I Unit	-6,081	2,378	-11,717	20	0,000

Source: Researcher's notes.
Performing the statistical analysis with the Student's t-test for related samples in Unit I yielded a significant result ($p<0.05$), confirming that the application of the methodological strategy of the historical-cultural approach and activity theory significantly influences the level of knowledge assimilation of descriptive statistics among third-year Sanitary Engineering students in the 2023-I semester.

Table 5. Student's t-test of pre- and post-test scores on knowledge assimilation in Probabilities among third-year Sanitary Engineering students in the 2023-I semester

	Average	Standard Deviation	t	gl	p-value
Pre test II Unit Post test II Unit	-6,462	2,302	-12,865	20	0,000

Source: Researcher's notes.

Performing statistical analysis with the Student's t-test for related samples in Unit II yielded a significant result ($p<0.05$), confirming that the application of the methodological strategy of the historical-cultural approach and activity theory significantly influences the level of knowledge assimilation of Probability among third-cycle Sanitary Engineering students.

GESj
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IV. Conclusions

- It was determined that the application of a methodological strategy based on the historical-cultural approach and activity theory significantly influences the level of assimilation of general statistics knowledge among third-year Sanitary Engineering students in the first semester of 2023.
- It was verified that the application of a methodological strategy based on the historical-cultural approach and activity theory significantly influences the level of assimilation of descriptive statistics knowledge among third-year Sanitary Engineering students in the first semester of 2023.
- It was analyzed that the application of a methodological strategy based on the historical-cultural approach and activity theory significantly influences the level of assimilation of probability knowledge among third-year Sanitary Engineering students in the first semester of 2023.

V. Acknowledgement

- To the Dean of the Faculty of Environmental Engineering at UNASAM, for allowing us to apply our data collection instruments to students in the Sanitary Engineering program.
- To the Academic Director of the Sanitary Engineering program for their willingness to implement our research project with second-year Sanitary Engineering students.

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Annex 1. Questionnaire

RESEARCH INSTRUMENT
PRE-TEST

1. In a study concerning the weights in kg of 50 employees of the “Luzuriaga” school in 2022.

62, 49, 84, 79, 56, 58, 43, 78, 67, 40
76, 55, 62, 42, 82, 88, 57, 46, 39, 57
59, 48, 74, 70, 51, 40, 35, 62, 52, 63
64, 53, 74, 64, 76, 60, 54, 45, 44, 35
65, 61, 45, 73, 61, 77, 45, 53, 64 67

a) Organize the data in a frequency table.
b) Sketch a histogram and frequency polygon.
c) Briefly comment on the distribution of the number of workers who weigh 50 kg or less.
d) Group this data into a frequency distribution with 5 class intervals and compare it with the table created in part (a).

2. The following information is available regarding the monthly income in soles of 6 teachers: 800, 700, 600, 800, 500, 750.

a) Determine the average salary and interpret it.
b) Determine the most frequently occurring salary and interpret it.
c) Determine the median and interpret it.

3. From the following information regarding the number of children of 20 teachers at the “Antonio Raimondi” school in 2023:

Number of children	Number of teachers
0	2
1	6
2	8
3	2
4	1
5	1

a) Determine the population and the sample.
b) Determine the variable.
c) Determine the average number of children and interpret it.
d) Determine the most frequent number of children and interpret it.
e) Graph the data.

4. Answer true or false to the following questions:

a) The arithmetic mean is the sum of all the data……..…..( )
b) The mode divides a data set into two equal parts… ……..( )
c) The median is the highest point in the data…… ( )
d) The sample is a part of the population……...( )

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POST TEST

1. Below, we have the information regarding the places of origin of 40 students from the elementary school, semester 2023-I.

Place of origin	No students
Yungay	10
Huaraz	16
Carhuaz	6
Mancos	4
Caraz	4
Total	40

Calculate and interpret the following if possible; otherwise, justify your answer:
a) The arithmetic mean.
b) The mode of the data.
c) The median of the data.

2. The following information shows the monthly salaries of 40 employees of the "Simón Bolívar" school in 2022.

Montly income	No of days
400 – 600	2
600 - 800	8
800 - 1000	20
1000 -1200	10
Total	40

a) Determine the average salary and interpret it.
b) Determine the median and interpret it.
c) Determine the mode and interpret it.

3. From the frequency curve of the salaries of 30 employees of a company, it is known that Mo = $200, Me = $220, and X = $250. Classify the following statements as true or false, justifying your answer:

a) The most frequent salary is $200, and more than half of the employees earn more than that amount.
b) A sum of $3300 guarantees the payment of half of the employees, and $7500 guarantees the payment of all employees.

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4. A sample of the amounts deposited by customers into the minimum checking accounts of a major bank revealed the following amounts in dollars.

124,	14,	150,	289,	52,	156,	203,	82,	27,	248,	39,	52,
103,	58,	136,	249,	110,	289,	251,	157,	186,	107,	142,	185,
75,	202,	119,	219,	156,	78,	116,	152,	206,	117,	52,	299,
58,	153,	219	148,	145,	187,	165,	147,	158,	146,	185,	186,

a) Organize the checking account balances into a frequency distribution.
b) Calculate measures of central tendency. Then interpret the important characteristics of the checking accounts and write a brief report summarizing these results for the bank manager.

5. The following information is available regarding the number of siblings of 5 students at the education school. Xi: 2 5 3 4.

a) Determine the average number of siblings and interpret it.
b) Determine the most frequent number of siblings among the students.

¡Thank you for your collaboration!