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# The teaching-learning of statistics for computer engineers focused on the project method

## La enseñanza-aprendizaje de Estadística para ingenieros informáticos, centrado en el método de proyectos

## O ensino-aprendizagem de Estatística para engenheiros de computação, com foco no método de projeto

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**ABSTRACT**
The professional training of computer engineers at the University of Pinar del Río has historically been determined by learning statistical content, which are key to understand their culture and professional identity. In the present study, a didactic conception was proposed for the teaching-learning process of Statistics energized by the project method. Theoretical methods (modelling, systemic-structural, analysis, synthesis, induction and deduction) and empirical methods (scale of attitudes towards statistics, teacher survey and document review) were used. The research was descriptive-cross-sectional. Working with scientific-professional projects favored the appropriation of statistical content. The experts assessed the proposed concept as positive and confirmed its validity, functionality, applicability and durability over time.

**Keywords:** vocational training; computer engineer; statistical education.

**RESUMEN**
La formación profesional de ingenieros informáticos en la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca" ha estado determinada históricamente por el aprendizaje de contenidos estadísticos, los cuales son clave para comprender su cultura e identidad profesional. En el presente estudio se propuso una concepción didáctica

para el Proceso de Enseñanza-Aprendizaje de la Estadística, dinamizado por el método de proyectos. Fueron empleados métodos teóricos (modelación, sistémico-estructural, análisis, síntesis, inducción y deducción) y métodos empíricos (escala de actitudes hacia la estadística, encuesta a profesores y revisión de documentos). La investigación tuvo carácter descriptivo-transversal. El trabajo con proyectos científico-profesionales favoreció la apropiación del contenido estadístico. Los expertos valoraron de positiva la concepción propuesta y corroboraron su validez, funcionalidad, aplicabilidad y perdurabilidad en el tiempo.

**Palabras claves:** formación profesional; ingeniero informático; enseñanza estadística.

**RESUMO**
A formação profissional dos engenheiros de computação na Universidade de Pinar del Río "Hermanos Saíz Montes de Oca" historicamente foi determinada pelo aprendizado de conteúdos estatísticos, que são fundamentais para entender sua cultura e identidade profissional. No presente estudo, foi proposta uma concepção didática para o Processo Ensino-Aprendizagem da Estatística, dinamizada pelo método de projeto. Foram utilizados métodos teóricos (modelagem, sistêmico-estrutural, análise, síntese, indução e dedução) e métodos empíricos (escala de atitudes em relação à estatística, pesquisa de professores e revisão de documentos). A pesquisa foi descritiva-transversal. O trabalho com projetos científico-profissionais favoreceu a apropriação do conteúdo estatístico. Os especialistas avaliaram o conceito proposto como positivo e confirmaram sua validade, funcionalidade, aplicabilidade e durabilidade ao longo do tempo.

**Palavras-chave:** formação profissional; engenheiro informático; ensino estatístico.

## INTRODUCTION

The training of computer engineers, as proposed in the 2030 Agenda for sustainable development (UNESCO, 2019), has a transcendental role for society, by transparently making visible the approach of the University to the business sector, putting science in function of production and services.

The Statistics Teaching-Learning Process (PEAE) enters into this line of thought, to contribute its contents (knowledge, skills and attitudes) and professional methods, as didactic keys that allow understanding its culture, identity and professional values. Statistics helps to make decisions in different contexts, from the processing of large volumes of information, after comparing, predicting, building indicators and displaying their results.

As part of the formation of the logical thinking of the professional, Statistics is located in the curriculum of the basic cycle, because it is essential to understand it as a precondition to the rest of the contents and for its application to the profession, by combining various associated concepts, types of language and representations, properties, procedures and arguments.

However, it is necessary to recognize the inertia and resistance to change of the teaching staff, to abandon traditional teaching and increase the perception of difficulty in statistical learning (Rodríguez and Gil, 2019), prioritizing the transmission of formulas and routine techniques. Batanero

(2001) specifies that the important thing is to develop a favorable attitude and reasoning that is integrated into the professional's way of acting.

From this perspective, for Alpízar (2007), the PEAE is:

> A problem-solving process, where real data sets are introduced, in order to draw the attention of students and encourage the study of this subject. The main objective is to make sense of the context in which the data is presented, by characterizing its qualities, through different representations and its proper interpretation (p. 98).

And essences are added that are reinterpreted here in the comments in parentheses:

- Sequence of events (based on socio-professional experiences).
- Interaction between subjects (which includes company tutors).
- Interdisciplinary between subjects (in classroom and business contexts).
- Improvement of professional performance (as an intentional, training, planned, multifactorial, contextualized and communicative process).

And it is that at present the World Higher Education cannot manage the training of the professional without recognizing the close link between university and company, so that the academic experiences assimilated in the classrooms are combined with the learning acquired in the productive and services sector. .

Assuming the criteria of Alpízar (2007) on the PEAE helps to recognize the importance of the project method as an effective didactic alternative that makes it possible to bring professional learning closer to real contexts.

Batanero (2001, p. 115), defines the project method as:

> The way of teaching with real problems through which students can develop their ideas, working the different stages in solving a real problem (plan the solution, collect and analyze the data, test the initial hypotheses and make a decision accordingly).

With this, a better appropriation of the contents and statistical methods is stimulated in the Computer Engineer by contextualizing the teaching, making the proposed learning experiences more relevant and shortening the distance between understanding and transferring conceptual nuclei (Alvarado, Galindo and Retamal, 2018).

This didactic alternative recognizes the role of Attitudes towards Statistics (AE) as an element of knowledge that must be curricular treated in the PEAE, and a condition to steadily improve academic performance (Mazas and Bravo, 2018; Ordóñez, Romero and Ruiz, 2019; Palacios, Caisa and Camacho, 2021).

The facto-perceptual analysis of the PEAE in the Computer Engineering career at the University of Pinar del Río revealed that the students:

- Do not recognize the importance of Statistics for their professional training.

- They abandon the resolution of statistical problems related to Computer Science.
- They historically show low academic performance.

In this way, a didactic conception to manage the PEAE today must take into account that learning requires attitudinal stimuli and methods that bring the professional reality closer to the act of learning.

Thus, the present investigation is part of this line of thought, and aims to propose a didactic conception for the PEAE energized by the project method, which allows the modification of AE in students of Computer Engineering at the University of Pinar del Río "Hnos Saíz Montes de Oca" (UPR).

## MATERIALS AND METHODS

The research, of a descriptive-transversal nature, was based on the dialectical-materialist method and assumed the mixed approach as a general orientation.

The chosen population corresponds to the 73 students who study Computer Engineering in the 2019-2020 academic years. Participation rates reached 100% coverage with respect to the total population, and the same percentage in the effective population. The population was made up mostly of men (69.86%), something common in this type of engineering career where the presence of women is very scarce despite increasing in the last decade.

No subject left incomplete answers (exclusion criteria), thus reducing the risk of subjectivity due to the size of the population and recognizing the commitment of the students with the results of the research.

methods were applied such as: modeling, systemic-structural, analysis, synthesis, induction and deduction; and at the empirical level such as: study of normative documents, survey of students, participant observation of a class system, group interview with professors, managers and tutors of companies, consultation with experts through the Delphy method.

According to Comas, Martins, Nascimento, and Estrada (2017), the functional invariant of EAs is structured in two components, each with three dimensions.

The *pedagogical component*, which has the following dimensions:

- Cognitive: conceptions and beliefs about the statistical attitudinal object.
- Affective or emotional: emotions and feelings that Statistics arouses, therefore they are more subjective; for example, feelings of rejection or interest.
- Behavioral or tendential: tendency to action or intention in a certain way; for example, how and when Statistics would be used.

The *anthropological component*, with the following dimensions:

- Social: perception and assessment of the role of Statistics in the sociocultural sphere of any citizen.
- Educational: interest in Statistics and its learning, vision of its usefulness for the student, their opinion on whether it should be included in the curriculum and perceived difficulty.
- Instrumental: utility towards other subjects, as a form of reasoning and as a cultural and interdisciplinary component.

In this way, the students answered the scale of attitudes towards Statistics, which takes into account this structure and is operationalized in 25 items: 14 affirmative (items 2, 4, 5, 7, 8, 10, 12, 13, 16 , 17, 18, 20, 22, 24), and 11 negative (items 1, 3, 6, 9, 11, 14, 15, 19, 21, 23, 25) (table 1).

The validity of the scale is assured, since Cronbach's alpha values of 0.83, 0.84, and 0.88 are reported for pretest and posttest.

**Table 1**- Components of the attitudes evaluated in the AE scale

| | **Anthropological** | | |
|---|---|---|---|
| **dimension Pedagogical dimension** | **Social** | **Educational** | **Instrumental** |
| Affective | 1, 11, 25 | 7, 12, 23 | 10, 13, 16, 20 |
| Cognitive | 2, 19, 21 | 4, 6, 17 | 3, 24 |
| Behavioral | 9, 18 | 8, 15, 22 | 5, 14 |

The participation of the students was authorized by the Directorate of the Faculty of Technical Sciences of the UPR, and by the Center for the Study of Educational Sciences, as the methodological body that coordinates this line research at the University.

The data was integrated into an Excel sheet and then analyzed using the statistical package SPSS version 24.

## RESULTS

It was found that articles 3, 6, 26, 114 and 115 of Ministerial Resolution No. 210/2007 and No. 2/ 2018 declares the importance of the university-business link and the need to train competent professionals. However:

- The Professional Practice program, as the main integrating subject, does not clarify what the rest of the subjects must do to integrate into it.
- The program of the subject Probabilities and Mathematical Statistics does not define the importance of Statistics for Computer Science.
- The culmination of studies works does not include statistical content.
- The project method is not declared essential for the PEAE.
- The curriculum does not declare the importance of the AE as content to promote.
- Academic performance in the subjects Mathematics Statistics I, II and Probability and Statistics shows low historical percentages (table 2).
- The contents and statistical methods are not systematized, in a procedural way.

**Table 2-** Historical percentage of academic performance in Computer Engineering

| **Subject** | **Excellent** | **Good** | **Fair** | **Bad** |
|---|---|---|---|---|
| Mathematics Statistics I | 26.03% | 23.75% | 20.55% | 24.20% |
| Mathematics Statistics II | 37.44% | 24.20% | 26.02% | 9.59% |
| Probabilities and Statistics | 14.42% | 11.53% | 34.13% | 27.88% |

These criteria and the theoretical analysis carried out justify the study of the AE as one of the essential nuclei to conceive the PEAE in a meaningful way. It is important that Statistics ensure stability, scope and functionality throughout the career as part of the culture, identity and professional values.

Table 3 shows the Mean scores (M) and the Standard Deviations (SD) that were obtained in each of the items that make up the dimensions of the scale of attitudes towards Statistics.

Negative questions on the scale are scored inversely. In this way, the total score is the

sum of the answers of all the items, which allows, according to Morales (1988), to avoid the problem of acquiescence by which some subjects tend to respond in agreement, whatever the content of the question.

**Table 3-** Mean scores and standard deviations of each item. of the scale of attitudes

| **Dimension** | **Items/Indicators** | **M** | **SD** |
|---|---|---|---|
| Affective/Social | Item 1. The statistical information that appears on some television programs bothers me. | 3.3290 | 0.9730 |
| Cognitive/Social | Item 2. Statistics help to understand today's world. | 4.0411 | 0.6549 |
| Cognitive/Instrumental | Item 3. Reality can be manipulated through statistics. | 2.6160 | 0.9810 |
| Cognitive/Educational | Item 4. It is essential in the basic training of the computer engineer. | 3.7810 | 0.9320 |
| Behavioral/Instrumental | Item 5. I use Statistics to solve problems in everyday life. | 3.4110 | 0.9980 |
| Cognitive/Educational | Item 6. More and better statistics should not be taught at school. | 3.4660 | 0.8670 |
| Affective/Educational | Item 7. I have fun in the classes that explain statistics. | 2.9450 | 0.9410 |
| Behavioral/Educational | Item 8. Statistics problems are easy for me. | 2.973 | 0.9710 |
| Behavioral/Social | Item 9. I do not understand the statistical information that appears in the press. | 3.425 | 0.9420 |
| Affective/Instrumental | Item 10. I like Statistics because it helps me to understand more deeply the complexity of certain topics. | 3.5800 | 0.969 |
| Affective/Social | Item 11. I feel intimidated by statistical data. | 3.4930 | 0.8840 |
| Affective/Educational | Item 12. I find the world of statistics interesting. | 3.4110 | 0.9100 |
| Affective/Instrumental | Item 13. I like serious jobs where statistical studies appear. | 3.3560 | 1.0190 |
| Behavioral/Instrumental | Item 14. I rarely use Statistics outside the University. | 2.658 | 1.1330 |
| Behavioral/Educational | Item 15. In Statistics class I never understand what they are talking about. | 3.5205 | 0.8516 |
| Affective/Instrumental | Item 16. I am passionate about Statistics because it helps to see professional problems objectively. | 3.1230 | 1.0130 |
| Cognitive/Educational | Item 17. Statistics is easy. | 2.6850 | 1.0390 |
| Behavioral/Social | Item 18. I find out more about the results of the exercises when graphic representations appear. | 3.3420 | 0.9750 |
| Cognitive/Social | Item 19. Statistics is | 3.8900 | 0.8750 |

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| | | | |
|---|---|---|---|
| | only useful for science people. | | |
| Affective/Instrumental | Item 20. I like to make problems when I use statistics. | 2.9860 | 0.8740 |
| Cognitive/Social | Item 21. Statistics is useful for everything. | 3.5480 | 1.001 |
| Behavioral/Educational | Item 22. I often explain Statistical problems to my classmates that they have not understood. | 2.7530 | 0.9830 |
| Affective/Educational | Item 23. If I could eliminate any subject, it would be Statistics. | 3.5750 | 0.9420 |
| Cognitive/Instrumental | Item 24. Statistics help to make more professional decisions. | 3.7808 | 0.8036 |
| Affective/Social | Item 25. I avoid statistical information when I read it. | 3.4790 | 1.0560 |

Scale of values: 1=strongly disagree; 2=disagree; 3=indifference; 4=agree; 5=strongly agree.

The results showed that the students have an AE of indifference with a slight inclination towards positivity. (Around three points), inferring that:

- They consider that Statistics make it possible to manipulate information.
- They do not have positive beliefs and conceptions towards statistical data.
- They find classes boring and unnecessary.
- They hardly use it (or do not use it) to solve professional IT problems.
- Most of the items have a high degree of variability (between 0.91 and 1.056), which can be interpreted as lack of knowledge about Statistics.
- The best valued item is number 2 "Statistics helps to understand today's world". This result reveals a singular significance in times of COVID-19, since at the international level (and particularly in Cuba) the importance of statistical culture has been evidenced to understand the entire volume of information and data issued.
- Similarly, the worst value is item 17, which shows the importance of this study in view of the need to transform the teaching-learning of Statistics.

As for the teaching staff, participant observation was carried out on a system of 11 teaching activities, together with the head of the Applied Mathematics discipline and the head of the Mathematics Department during the 2019-2020 school years. In addition, the observation was complemented with a group interview with 22 professors from the faculty, seven directors (one dean, one vice-dean of Vocational Training, two heads of department and three heads of discipline) and five tutors from Software Development companies.

The indicators evaluated, and presented below, confirm that teachers:

- They excel in their science of origin; however, they do not pay enough attention to psycho pedagogical preparation and the Professional Model.
- They do not manage the PEAE in a professionalized and interdisciplinary manner.
- The master class with large volumes of content prevails.
- They do not create conditions for learning that includes experiences in companies.

- It accentuates the divorce between the university and the productive and service sector.

To corroborate these results, the methodological triangulation technique was applied, obtaining the following diagnostic regularities:

- The PEAE is not managed from the science-teaching-profession relationship.
- In the PEAE, the project method is not applied to boost professional training, taking advantage of business contexts.
- The PEAE does not stimulate the modification of the AE in the students.
- The PEAE does not promote the appropriation of statistical content and methods, and their transfer to the object of the profession.

Undoubtedly, the current conception of the PEAE requires changes from the theoretical-practical point of view.

## DISCUSSION

### Main scientific ideas that support the PEAE

As it has been defended up to this point, an effective alternative to transform the PEAE is the use of the project method, where the statistical contents and methods are interpreted as professional contents and methods, and become keys to university training of culture, identity and professional values.

Based on these assumptions, a system of scientific ideas and principles that support and support the logical-conceptual structure of the proposed didactic conception is proposed below, taking as a guiding and dynamic compass the project method and its potential to modify the AE in Computer Engineer.

1. The PEAE is an integrated system of didactic components that contributes to the modification of AE and the formation of the professional performance mode of the Computer Engineer, in connection with the business context.

2. The PEAE for the Computer Engineering career is professionalized, fundamental and systematized in the scientific-professional project.

3. The scientific-professional Statistics project is structured in developmental stages that respond to the methodological work system of the career group and academic year.

Not because they are repeated in one way or another, these ideas cease to be relevant, if one thinks of the new perspective of integrating the university and the company as a support for the Shared Professional Training Model and as responsible for the competent training of university students.

From its full understanding, the PEAE is interpreted as: "The professionalized, mediated and interdisciplinary path that, under the didactic performance of the teacher, favors the modification of AE and the conscious appropriation of the content by the students, in an environment of scientific - professional project, labor exploration, participatory and communicational" (p. 38).

The PEAE becomes professional when all its didactic components (personal and non-personal) are designed taking the mode of professional performance as a guiding compass, in such a way that it systematizes

in each action (and context of professional development) the work algorithm of the Computer Engineer and its mode of action.

The PEAE is mediated when the didactic intervention is consciously oriented (from the career, year and discipline group) towards personalized attention to the student's educational progress, in correspondence with the year's educational project and with their professional actions, responsible in each Learning context. It is necessary, then, a systematic diagnosis, that professional method and means form part of the methods and means of teaching Statistics, and that the step is taken from purely classroom scenarios to contexts of professional development in companies.

The PEAE is interdisciplinary, if the cognitive nodes of Statistics are a gradual and progressive derivation of those elements of knowledge present in the curriculum and that complete the scientific-professional picture of the engineer in the academic year and career. This is achieved as a result of the methodological work of the pedagogical collective. In this way, the fragmentation of the contents that supports an abstract and decontextualized teaching is broken.

As Mena and Mena (2020) state, in the professional process, seen as the set of logically articulated and regulated actions to solve professional problems in response to a social demand that requires the use of the work object's own resources, there is an object of the profession to which the object of each science turned into a subject must be integrated, such as Statistics.

Then, attention to it is essential in each discipline, subject and area of the curriculum; In each case, a statistical design should be projected that enhances the professional in the development of the training process, which is necessarily linked to the mode of action and the professional problems of the PEAE.

For Abreu and Soler (2015), a professional problem is a situation or conflict that arises in the professional process that generates the need to solve it, for which one or more objectives are determined; it is a social necessity that determines the character of the PEA, and the culture, values and professional identity inserted in the professional process.

On the other hand, it determines what professional statistical content should be oriented in the PEA, avoiding promoting the teaching of science for science's sake and orienting science for the profession. In its cognitive dimension, the statistical contents must include the mastery (at the application level) of the professional's mode of action and the computer engineer's work algorithm. Its procedural dimension is based on the system of statistical skills that are derived from the professional skills of the career.

Frequently, when faced with a problem situation of a professional profile related to the development of software, in order to manage information and return certain reports that require statistical analysis, students must apply the contents, methods and statistical techniques, harmonizing them with the phases to develop a software (table 4).

**Table 4-** Relationship between statistical skills and computer work algorithm

| **Stages of statistical research** | **Phases of software development** |
|---|---|
| Approaching the problem | Business modeling |
| Collection of data to be processed | |
| Organization, analysis and interpretation | Requirements |
| | Analysis and design |
| Obtaining conclusions about the problem raised | Implementation |
| | Test |
| | Installation |

An effective alternative to achieve this aspiration is the application of the project method. In the field of Statistical teaching, various researchers have implemented it to improve the learning of content, methods and procedures. The diversity in its treatment is innovative in this research, since statistical science and the profession are integrated as a fundamental epistemological nucleus to stimulate the formation of the mode of action of the Computer Engineer in the PEAE, both in the university and in the company.

From this perspective, the scientific-professional project is defined as:

> A teaching-learning method that favors the appropriation of statistical content and its application to the solution of problems of professional relevance designed individually or collectively. It requires mastering the phases of a statistical investigation, the mode of action of the Computer Engineer and showing a positive predisposition for teamwork, in an environment of labor, participatory and communicational exploration (p. 4).

The term exploration is interpreted as the detailed recognition of the work context through the professional problems oriented in class. From this perspective, each problem, derived from the Professional Model, has a real scenario in the company (state or private) and responds to the objectives outlined by Professional Practice as the main integrating subject.

The fact that it responds to an environment of work exploration means that statistical knowledge cannot be understood apart from its context of application, nor applied only to abstract problems that are not found in the daily (and professional) life of the student. Statistical concepts and techniques must be presented in a contextualized way in the work-research practice. Statistical skills (data collection and analysis, drawing conclusions about the problem posed, predictions, decision-making) are positively encouraged if they are integrated into work practice.

That it responds to an environment of participatory exploration means that the participation of students in group work and the sociocultural perspective in training contexts is required, thus promoting active learning strategies. It supposes, therefore, the interaction between the individual work of the student and the cooperative, where the teacher participates as a guide of the process.

That it responds to an environment of communicational exploration means that the ability to express (orally or in writing) the analysis and interpretation of information from the data extracted from the surrounding situations is based. It is essential to develop students' communicative competence as a way to expand their statistical thinking skills.

The quality scope of the scientific-professional Statistics project depends, in the first place, on the methodological work carried out in the career, year and discipline group, to identify the cognitive nodes that must be consciously appropriated by the students. These elements of the professional process have an interdisciplinary approach and respond to the training objectives of the academic year, oriented from the Professional Practice subject.

The Professional Practice's mission is to integrate the related contents of different subjects that are taught in the academic year, promoting mastery of the Computer Engineer's mode of action. These contents receive didactic treatment in the scientific-professional project, since they show a relationship in the interdisciplinary order with the way of solving professional problems, from the point of view of the relationships of the phases of a Statistical investigation and the stages of development of a computer product.

Secondly, the teacher's didactic performance needs to ensure quality management of the PEAE. It must establish interdisciplinary relationships in each workshop in which the project is developed to favor the professional training work of the students from the mode of action, as a result of the development of integrating and professional activities that guarantee their individual and collective commitments.

By linking Statistics with the rest of the subjects through Professional Practice, there is an increase in efficiency rates in the domain of skills and knowledge to be acquired. Oriented from a professional investigative approach, it will allow the development of more complex actions that pull the development and mode of action of the Computer Engineer, with independence and creativity.

The scientific-professional project of Statistics is managed by the professors of the group of the year, specialists of the career and tutors of the company; all as experts make up the pedagogical group. In addition, the learning scenarios can also be developed in the companies themselves, to stimulate the modification of the AE that favor the appropriation of the statistical contents in the full production process. In this way, the socio-affective ties of the students are guaranteed when they interact with the workers in real production conditions.

The efficiency with which students go through each stage of the project will mark their scope in solving professional problems. This transit must be dynamic and facilitate the interaction of the basics with the professional at the level of students' thinking, allowing them to modify their AE and face the learning of professional content with a positive predisposition for change.

It is essential to understand that in the scientific-professional Statistics project for Computer Engineering students, the academic production of statistical content and professional practice as a work vocation are integrated. For this reason, it is necessary to guarantee the pedagogical preparation of the company's personnel that participate in the project. They must be able to share their professional experience with students, based on their training in Statistics and scientific research.

The use of projects in the PEAE makes it possible to attenuate the distance between understanding and application of content to the profession, and promotes significant learning, group work and the development of student reflection and autonomy.

The use of this teaching method is justified because Statistics is inseparable from its application, otherwise they are just meaningless formulas and graphs; In addition to how useful it is for solving problems in any other sphere, a criterion that is transcendent as the basis of the proposal made.

The evaluation of the project must be carried out in several stages, providing students with help in its execution. The interest of the project, the correctness of the statistical techniques and interpretation, the clarity of

the report, as well as the integration of the student in the team, their individual effort and their contribution to the collective work will be taken into account. A good evaluation must ensure that the student learns and not only passes (Batanero, 2009; Estrada, Bazán and Aparicio, 2013; Salinas and Mayén, 2016).

Statistical projects increase motivation and allow the modification of attitudes in students during the PEA, allowing:

- Contextualize the subject and make it more relevant based on meaningful data.
- Reinforce interest, especially if they are the ones who choose the topic.
- Learn better what data is in the context of the profession.
- Stimulate precision, variability, reliability, measurability, bias.
- Understand that this is a useful tool for solving professional problems.

This condition is relevant, since the new proposal must be assessed in the career; year and discipline group (career, discipline and year) so that the contribution, commitment and coordination of all educational agents and agencies is guaranteed. In addition, it is essential to structure the project in development stages that enhance the comprehensive training of the professional.

In this sense, the development stage is understood as:

> To the state in which the subjects (students, professors, company tutors), the learning objects (academics and professionals) and the developing scenarios (classrooms and business) converge (directly or indirectly), to manage professional training, from knowing their socio-scientific and socio-professional needs (p. 50).

**Developing stages of the PEAE for computer engineers**

The scientific-professional Statistics project is structured in the following development stages:

**First stage.** Diagnosis of the developer context

The objective of this stage is to assess the current state and perspective of the development context in which the professional training of the student will take place. It is based on the methods of obtaining information on reality that allow us to identify weaknesses, threats, strengths and opportunities for decision-making and methodological procedure. Next, the actions that make up the project are conceived. These must respond to what, why, when and how to learn during the solution of the oriented professional problem. All the subjects converge to carry out the methodological work based on knowing the results of the diagnosis made to the students.

**Second stage.** Data Collect

In this phase the sources, methods and techniques for data collection are analyzed, the student needs to obtain data from various sources through different techniques (surveys, databases, press reports, censuses), and correspond to various scales of measurement and Statistical variable types.

**Third stage.** Organization, analysis and interpretation of data

Its objective is to organize, analyze and interpret the data collected, putting into practice all the planned actions, according to the roles of the subjects in the project. The student, with the help of the academic team, solves the tasks within the established period of time, demonstrating economy of thought. Interpretations must be made based on the development context of the problem posed; it is the mathematical stage of the problem.

**Fourth stage.** Drawing conclusions

Its objective is to assess the results in each of the designed actions and the conscious appropriation of the content by the students as a result of the modification of their EA. The results achieved the positive contributions, the creativity, the individual and collective achievements, the barriers presented are valued. The results obtained are presented in written and oral form, providing a summary of the work carried out. It also reinforces the process of statistical reasoning, by having to tell another person about their decisions, actions and interpretations.

**Principles that drive the PEAE**

The references and theoretical bases assumed in the research allow establishing a system of principles whose logical-gnoseological and practical functions govern the PEAE for students of Computer Engineering. The complexity of the object studied required formulating and identifying a system of principles that, supported by previous proposals, respond to the formation of the Computer Engineer in a unique way.

**Principle of the governing character of the Educational Project of the academic year**

The Educational Project of the academic year, derived from the Educational Project of the career, must contain among its tasks the curricular design of the PEA of each subject and how it is expected to contribute to overcoming the professional's training objectives. In this way, the scientific-professional Statistics project pays attention to the socio-scientific and socio-professional needs of the students and encourages them to modify their AE and, consequently, to the conscious appropriation of the contents and the formation of the mode of action of the Computer Engineer.

**Principle of the coordinating nature of Professional Practice**

This principle is considered for its coordinating nature, because in the main integrating subject of the academic year the aspiration to be achieved in the professional according to the stage is specified. Therefore, if it is the synthesis of the professional model, it must strategically coordinate the contributions of all the subjects of the curriculum, so that the integrated work of the pedagogical group is achieved, in order to train the Computer Engineer.

**Principle of the interdisciplinary nature of the professional educational process**

It bases, in essence, the science-teaching-profession link during the PEAE for Computer Engineering students. It has at its base the integration of contents in its singularity and the university-business integration in its generality. It declares the need to identify the basic nuclei of Statistics and the profession and establish the connections for their teaching.

**Principle of the active character of the student for the appropriation of the content**

It establishes the domain of the roles of students and teachers in the scientific-professional project. The student as protagonist of the PEAE; the teacher and tutors of the company as didactic mediators of the training process.

These principles constitute a system that goes from the general-external to the particular-internal; that is, from the influence of each teaching activity in the training of the professional, to the role of the class in the conscious appropriation of the statistical content by the students. In this way, the developing nature of the PEAE is sustained and structured as a result of the systemic nature of its didactic components (figure 1).

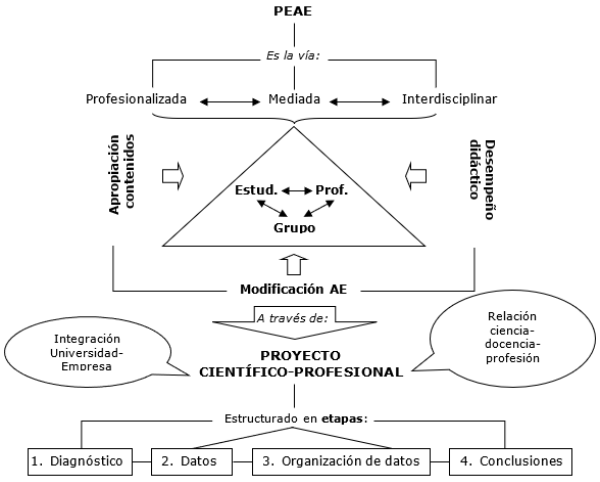


**Fig. 1-** Logical-conceptual structure of the PEAE of the didactic conception of the PEAE

**Implementation and expert opinion**

The implementation of the PEAE for the Computer Engineer requires:

- Know the socio-scientific and socio-professional needs of the students.
- Design scientific-professional projects that derive from the educational project of the academic year and guarantee the contributions of educational agents and agencies necessary for the professionalization of the PEA.
- Guarantee the commitment of the subjects involved in vocational training.

In order to assess the theoretical validity of the projective didactic conception, experts were consulted through the Delphy method criteria _ in a row for his selection were the following :

- Prestige achieved in their professional performance.
- Possess a scientific Master's degree or a scientific Doctor's degree.
- Hold the teaching categories of assistant or full professor.
- Have more than 10 years of experience in Higher Education.
- Be willing to participate in research.

It had the collaboration of 25 experts. When assessing their degree of competence, only the criteria of 20 were taken into account, based on knowing that their competence coefficient **(for**) was evaluated with a medium or high level. Similarly, all the indicators were assessed as quite adequate (figure 2).

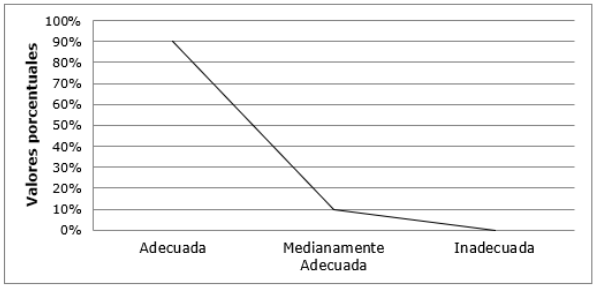


**Fig. 2-** Representation of the expert opinion matrix

According to the criteria provided by the experts based on the indicators evaluated, the didactic conception for the PEAE in Computer Engineering is valid, functional, applicable and lasting over time.

As a result of the application of the theoretical and empirical methods, it can be concluded that the study of the AE around the world (in general), in Cuba (in particular) and in the Computer Engineering career at the University of Pinar del Río "Hermanos Saíz Montes de Oca" (in the singular), reveals the need to change the educational act of teaching this discipline to enhance the socio-individual act of learning it. The results of the EAEE globally indicate an attitude of indifference with an inclination towards positivity in these students. However, they recognize the importance of Statistics to understand the world, which provides added value for the appropriation of the volume of information and data generated in times of COVID-19.

This result of indifference It may be generated by an active didactic conception of the PEAE for Computer Engineering, which does not focus on meeting the socio-scientific and socio-professional needs of students, and lacks professional training focused on the science-teaching-profession relationship. This is reaffirmed (and has didactic implications) in the limitations shown to integrate with the business context in a coherent way, in the levels of indifference detected before the study of the subject, in the deficiencies in the appropriation of the statistical contents and in the low didactic performance of teachers in various professional training activities.

In this way, a didactic conception is projected in whose guiding axis the PEAE is conceived as the professionalized, mediated and interdisciplinary way that, under the didactic performance of the teacher, favors the modification of AE and the conscious appropriation of the professional content by the students in an environment of scientific-professional project, labor exploration, participatory and communicational.

For this reason, and as a didactic and dynamic support for the early training of this professional, it is taken into account that the scientific-professional project is a teaching-learning method that favors the appropriation of statistical content and its application to the solution of problems of professional relevance, designed individually or collectively. It requires mastering the phases of a statistical investigation, the mode of action of the Computer Engineer and showing a positive predisposition for teamwork, in an environment of labor exploration, participation and communication.

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**Conflict of interest:**

The authors declare not to have any conflicts of interest.

**Authors´ Contribution:**

The authors have participated in the writing of the work and analysis of the documents.