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The teaching and learning process of Statistics in the training of professionals in Physical Education

[La enseñanza-aprendizaje de la Estadística en la formación del profesional en Cultura Física]

[O processo de ensino-aprendizagem da Estatística na formação de profissionais em Cultura Física]

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Abstract

Introduction: The constant generation of data, the growing technological advance and the continuous evolution of social processes, give Statistics a significant place in the multiple areas of knowledge. In Physical Culture, it is weighted for its transversality and contribution in social and sports environments from the four profiles of professional graduates. Based on the diagnosis made at the University of Physical Culture and Sports Sciences "Manuel Fajardo" on the application of statistical techniques, limitations were detected in first-year students of the regular day course, and in teachers of the subject Computer Science and Data Analysis on the dimensions and indicators that characterize the variable under study. these have become a research problem.

Objective: To develop a didactic strategy for the application of statistical techniques from the teaching-learning process of the subject Computer Science and Data Analysis in the training of professionals in Physical Culture.

Materials and methods: A scientific procedure was used for the study that integrated methods from the theoretical, empirical and statistical-mathematical levels, supported by the dialectic-materialist.

Results: The quasi-experiment supported the practical application of the proposal, preceded by a prognostic assessment of its validity, obtained from a group of experts through the ATJ matrices.

Conclusions: The results of the implementation of the strategy corroborate the prognostic values and show significant changes between the experimental and control groups, which corresponds to the demands of Higher Education.

Keywords: learning strategies, statistics, levels of assimilation.

Resumen

Introducción: la constante generación de datos, el creciente avance tecnológico y la continua evolución de los procesos sociales, otorgan a la Estadística un lugar significativo en las múltiples áreas del saber. En la Cultura Física se pondera por su transversalidad y contribución en los entornos sociales y deportivos desde los cuatro

perfiles de egreso profesional. A partir del diagnóstico realizado en la Universidad de Ciencias de la Cultura Física y el Deporte "Manuel Fajardo" sobre la aplicación de técnicas estadísticas, se detectaron limitaciones en estudiantes de primer año del curso regular diurno, y en profesores de la asignatura Informática y Análisis de Datos sobre las dimensiones e indicadores que caracterizan a la variable en estudio, devenidas estas en problema de investigación.

Objetivo: elaborar una estrategia didáctica para la aplicación de técnicas estadísticas desde el proceso de enseñanza-aprendizaje de la asignatura Informática y Análisis de Datos en la formación del profesional en Cultura Física.

Materiales y métodos: para el estudio se utilizó un proceder científico que integró métodos del nivel teórico, empírico y estadístico- matemático, respaldados en la dialéctica-materialista.

Resultados: el cuasi-experimento sustentó la aplicación práctica de la propuesta, precedida por una valoración pronóstico de su validez, obtenida de un grupo de expertos a través de las matrices ATJ.

Conclusiones: los resultados de la implementación de la estrategia corroboran los valores pronósticos y muestran cambios significativos entre los grupos experimentales y de control, lo que se corresponde con las exigencias de la Educación Superior.

Palabras clave: estrategias de aprendizaje, Estadística, niveles de asimilación.

Resumo

Introdução: A constante geração de dados, o crescente avanço tecnológico e a contínua evolução dos processos sociais, conferem à Estatística um lugar significativo nas múltiplas áreas do conhecimento. Na Cultura Física, é ponderada por sua transversalidade e contribuição nos ambientes sociais e esportivos a partir dos quatro perfis de profissionais graduados. Com base no diagnóstico realizado na Universidade de Cultura Física e Ciências do Desporto "Manuel Fajardo" sobre a aplicação de técnicas estatísticas, foram detetadas limitações nos alunos do primeiro ano do curso regular, e nos docentes da disciplina de Informática e Análise de Dados sobre as dimensões e

indicadores que caracterizam a variável em estudo. estes se tornaram um problema de pesquisa.

Objetivo: Desenvolver uma estratégia didática para a aplicação de técnicas estatísticas a partir do processo de ensino-aprendizagem da disciplina Ciência da Computação e Análise de Dados na formação de profissionais em Cultura Física.

Materiais e métodos: Para o estudo, foi utilizado um procedimento científico que integrou métodos dos níveis teórico, empírico e estatístico-matemático, fundamentados na dialética materialista.

Resultados: O quase-experimento apoiou a aplicação prática da proposta, precedida de uma avaliação prognóstica de sua validade, obtida de um grupo de especialistas por meio das matrizes ATJ.

Conclusões: Os resultados da implementação da estratégia corroboram os valores prognósticos e mostram mudanças significativas entre os grupos experimental e controle, o que corresponde às demandas do Ensino Superior.

Palavras-chave: estratégias de aprendizagem, estatística, níveis de assimilação.

Introduction

The need to apply Statistics in a data-generating society and the rapid advancement of new technologies constitute the great combination of applied research. The Manuel Fajardo University of Physical Culture and Sports Sciences (UCCFD), an institution responsible for training in the fields of Sports, Physical Education, Prophylactic and Therapeutic Physical Culture, and Recreation, recognizes the value of its social mission and the importance of the proper application of statistical techniques in research projects. Therefore, a Physical Culture professional must possess the necessary statistical tools to develop work strategies and solve problems that arise using technological resources (Ross & Leyva, 2018; Roque, 2022). The teaching-learning process (TLP) of the Computer Science and Data Analysis (CSDA) course, hereinafter SDA, is considered the

starting point for the application of these contents and, in particular, of statistical techniques.

In this sense, we agree with Valdés and Carracedo (2023) who consider that the PEA is the moment of the pedagogical process where the joint activity of the teacher and the students reaches its highest level of systematicity, intentionality and directionality, and they also recognize it as the process of transmission of culture, development of habits and skills that enrich the knowledge of the individual, as well as the active, reflective, socializing and integrated nature of learning. For their part, Pulido and Barreiro (2020) propose that the teacher has to specify the level of assimilation that must be achieved in the treatment of the contents established in the programs, which is closely related to the evaluation of learning outcomes. Among the most frequent classifications of levels of content assimilation is that given by Álvarez de Zayas (1999) who states three levels: reproductive, productive and creative. These classifications warn of a progressive transition in cognitive order, regarding the skills that the student must acquire during the treatment of the content, for such reasons they are considered fundamental from the planning of the PEA of the IAD subject for the application of statistical techniques.

Achieving efficiency in this process leads the authors to agree with the position of Alvarado *et al.* (2021) and Wei *et al.* (2023) when they propose that the use of learning strategies is highly desirable as a support tool that makes the student's assimilation process viable at university. These strategies are defined in relation to conscious and intentional decision-making, in which students choose and activate the knowledge they need to respond to the demands of professional and personal learning based on the conditions of the educational situation in which such learning occurs. Furthermore, this approach allows students to consciously monitor their learning and contribute to their training. This idea suggests strategic teaching as a viable and innovative path to content learning, particularly for the application of statistical techniques. There are various classifications of learning strategies; authors such as Castellanos *et al.* (2002) and Alvarado *et al.* (2021) agree in classifying them as cognitive, metacognitive, and learning

support strategies. These in turn are associated with the will, capacity and autonomy that students have, related to the learning processes they develop.

Based on these elements and with the aim of promoting statistical training, which is expected to become a curricular strategy, the objective of this study is to develop a teaching strategy for the application of statistical techniques from the PEA of the IAD subject in the training of professionals in Physical Culture.

Materials and methods

For the development of the study, two surveys were assumed from the literature, and although these retained their initial characteristics, a test was applied to ensure their reliability: Cronbach's Alpha coefficient. This method is considered a simple and reliable way to validate a scale and as a measure that quantifies the correlation existing in it (Castañeda *et al.*, 2024), that is, it is the average of the correlation of the items that are part of an instrument. In this way, the internal consistency of the instrument is determined, from the variance of the individual items and the variance of the sum of the items evaluated, making use of the SPSS statistical package (v.25) (Statistical Package for the Social Sciences). Through the procedures adopted by Burguet *et al.* (2019), 19 experts were selected from the 23 initially considered, from the areas of Statistics and Research Methodology. A pedagogical test was used in the process of validating the proposal.

Among the methods used for the study are:

The historical-logical: it allowed us to understand the evolution and development of the different study plans, and with them, of the discipline and subject that contain the Statistics topics within the PEA for the training of the professional in Physical Culture.

The inductive-deductive approach: enabled analysis from the most general elements that make up a teaching strategy to satisfy the needs of integrating Statistics into the training process of the Physical Culture professional.

The structural-functional system: facilitated the establishment of systemic links between theoretical references, empirical investigations and the components of the teaching strategy, as well as the coordination relationships between each of its components.

Document review: this enabled the review of curricula, the program of the discipline and subject in which Statistics topics are taught, as well as scientific and research papers and attendance and evaluation records, all of which allowed for a characterization of the current status.

Expert criteria: based on the selection of experts, it provided an assessment of the reliability of the surveys applied, using Cronbach's Alpha coefficient, and obtained results in the ATJ matrices for a theoretical assessment of the strategy.

Surveys: these were administered to IAD professors who regularly taught classes in the regular daytime (CD) program, with the aim of determining their application of statistical techniques during classes. The student survey made it possible to determine limitations on the application of statistical techniques in IAD classes in the first year of the CD program, based on the learning situations generated during the training of professionals in Physical Education.

Data triangulation: allowed for cross-checking of the results obtained from the application of the methods: document review, surveys, and pedagogical testing.

The ATJ matrices: predicted the validity of the teaching strategy before its implementation, through a team of 19 experts.

The pedagogical test: This was used with the students after the strategy was implemented, with the aim of comparing the results obtained between the experimental and control groups, based on learning evidence.

From the statistical-mathematical method: the calculation of absolute and relative frequencies was applied in order to determine the representativeness of the group data obtained by dimensions and indicators. Likewise, central tendency statistics were

calculated, Cronbach's Alpha coefficient was used to determine the reliability of the surveys, and the nonparametric Mann-Whitney U test was used to verify the significance of the changes in each indicator and dimension between the experimental and control groups after the strategy was applied.

The quasi -pedagogical experiment: evaluates the functionality of the teaching strategy by testing a causal hypothesis from the empirical intervention study in the first-year population of the CD. Students were not randomly assigned to groups; rather, pre-formed groups were used.

Results and discussion

The sample of students and teachers were represented (Table 1)

Table 1. - Population and sample

Participants	Population	Sample	%
Students	488	234	48
1st year	(16 groups)	(8 groups)	
Teachers	11	7	63.6

The variable was parameterized in three dimensions, the process relationships (Table 2)

Table 2. - Variable parameterization. Relationship between dimensions, indicators, instruments and methods

Variable	The application of statistical techniques from the PEA of the IAD subject in the training of professionals in Physical Culture
Classification	Qualitative, ordinal, complex, dependent
Operational definition	It is the process that allows the transition through the levels of assimilation of the content (reproductive, productive and creative) from the processing of data sets referring to the four professional graduation profiles (Prophylactic and Therapeutic Physical Culture, Recreation, Physical Education and Sport) from the development of the PEA of the subject and on the statistical conceptual bases that the student masters, in close relation to his academic-social environment.

Dimension 1: Reproductive assimilation level		Investigations empirical/scales evaluative	Purpose: Diagnosis (D) and Validation (V).			
			DD/V D/V V			
			Inst 1	Inst 2/ items	Inst 3/ items	Inst 4/ items
Indicators	1.1-Knowledge of basic statistical concepts	Document Review (Guide)(1)	X		X	X
	1.2-Usefulness and applicability of statistical techniques	Questionnaire for teachers (2) Student Questionnaire (3)	X		X	X
	1.3- Cognitive, metacognitive and learning support strategies (low complexity)	Pedagogical test (4) Ordinal scale Yes (loud) Sometimes (half) No (low)		X	X	X
Dimension 2: Productive assimilation level		Investigations empirical/scales Evaluative	Purpose: Diagnosis (D) and Validation (V).			
			DD/V D/V V			
			Inst 1	Inst 2	Inst 3	Inst 4
Indicators	2.1-Need to use statistical techniques	Document Review (Guide)(1)	X		X	X
	2.2-Identification and application of statistical techniques according to the context studied	Teacher surveys (2) Student survey (3) Pedagogical test (4) Ordinal scale	X		X	X
	2.3-Cognitive, metacognitive and learning support strategies (moderate complexity)	Yes (loud) Sometimes (half) No (low)		X	X	X
Dimension 3: Creative assimilation level		Investigations empirical/scales evaluative.	Purpose: Diagnosis (D) and Validation (V).			
			DD/V D/V V			
			Inst 1	Inst 2	Inst 3	Inst 4

Indicators	3.1- Application of statistical techniques in practical situations generated from training or in scientific-research work	Document Review (Guide)(1) Teacher surveys (2) Student survey (3) Pedagogical test (4)	X		X	X
	3.2- Recognize mastery of the application of statistical techniques	Ordinal scale Yes (loud) Sometimes (half)	X		X	X
	3.3-Cognitive, metacognitive and learning support strategies (high complexity)	No (low)		X	X	X

To parameterize the dimensions and indicators, we used the ordinal rating scale proposed by Collazo (2016) and adjusted to the context of the study. It comprises three levels: 1 (Low), 2 (Medium), and 3 (High). The first level represents undesirable outcomes; the second level represents outcomes far from what is desired; and the third level represents desired outcomes.

Regarding the reliability of the student and teacher surveys, 87.7% and 74.5% of evaluators, respectively, agreed with responses ranging from adequate to very adequate when evaluating the relationship between the indicators and dimensions and items in the instrument used to measure the state of the variable under study. The calculation of Cronbach's alpha coefficient for the student and teacher surveys, based on their 12 and six respective items, reflects values of 0.801 for the former and 0.872 for the latter, which determines a high level of reliability for their application.

The values obtained from the application of the instruments during the diagnosis allowed the evaluation of the indicators, dimensions and the variable, (Table 3)

Table 3. - *Evaluation of the indicators, dimensions and variables based on the frequencies calculated by instruments*

Dimension 1: Reproductive assimilation level			
Indicators	Survey to students	Survey to teachers	Assessment
1.1	B	-	B
1.2	B	-	B
1.3	B	TO	M
Dimension evaluation			Level 1 (Low)
Dimension 2: Productive assimilation level			
2.1	M	-	M
2.2	B	-	B
23	B	M	B
Dimension evaluation			Level 1 (Low)
Dimension 3: Creative assimilation level			
3.1	B	-	B
3.2	B	-	B
3.3	B	B	B
Dimension evaluation			Level 1 (Low)
Evaluation of the variable			Level 1 (Low)

From the results obtained and represented in the table, it can be summarized that the variable under study is characterized by the deficiencies described below:

- There are difficulties in the treatment provided to the subject to establish its motivations, which limits the student's willingness to apply the statistical content.
- The identification, application and assessment of statistical techniques in correspondence with the variables to be investigated from the subject's PEA and directed to the subjects of the exercise of the profession for the realization of scientific-research work from the different disciplines of the career is insufficient.

- The development of learning strategies by students is not shown in a coherent and adequate manner.
- There is no evidence of adequate mastery of learning strategies among teachers, nor of their potential to contribute to reflective and self-regulated learning of statistical techniques.

In order to solve these problems, a teaching strategy was designed based on the assumed structural components of Linares *et al.* (2022), all contextualized to the research. The graphic representation of the strategy (Figure 1)

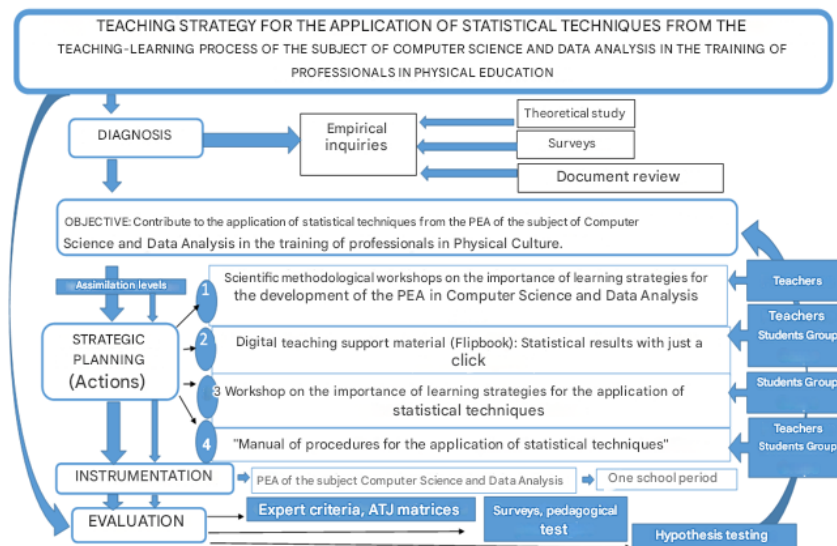


Fig. 1. - Graphic representation of the strategy

The starting point for developing the teaching strategy was the results of the pilot study conducted on the documentary review of scientific and research work, attendance and evaluation records, and documents demonstrating the results of visits to IAD subject teachers, as well as the review of documents governing its development.

Strategic planning

Strategic Action 1: Implementation of four scientific-methodological workshops at the teaching staff level on the importance of learning strategies and their influence on the development of content assimilation levels, based on the PEA of the IAD subject in the training of professionals in Physical Culture.

Strategic Action 2: Design and implementation of online digital materials (flipbooks or animated books): Statistical results are available at the click of a button, accessible via an email address (<https://heyzine.com/flip-book/bb627624cd.html>) or QR code. This illustrates and describes procedures for working with statistical techniques and SPSS software, in accordance with the IAD course syllabus.

Strategic Action 3: Delivery of a workshop for students from the experimental groups, on the importance of learning strategies for the application of statistical techniques from the PEA of the IAD subject in the training of professionals in Physical Culture.

Strategic Action 4: Design of a “Manual of procedures for the application of statistical techniques” on the implementation of learning strategies integrated into the development of assimilation levels, from the PEA of the IAD subject in the training of professionals in Physical Culture.

The strategy was implemented in synchronization with the development of the IAD course during the 16 weeks of the semester's academic period. The consecutive development of its components, the implementation of the resulting materials, and the development of new knowledge aimed at putting learning strategies into practice determines the teacher's intention to conceive the development of the levels of content assimilation from the planning of the guiding component of the process.

In order to predict the validity of the proposal, it was decided to apply the ATJ Matrices. This matrix arrangement is based on participatory heuristic techniques in the context of Physical Culture (Morales *et al.*, 2021). According to the referenced authors, it is a technique made up of four matrices that determine four dimensions: viability,

consistency, reliability, and legitimacy. Taking the results of the application and their analyses as support, it is concluded by emphasizing that the proposed teaching strategy is viable (9.5), consistent (9.4), reliable (9.5), and legitimate (9.6). The overall average achieved was 9.5, which allows predicting the validity of the proposed teaching strategy and the probable efficiency of its results before its implementation.

For the realization of the quasi-experiment, the null hypothesis (H_0) $\mu_e = \mu_c$ was identified: () the mean of the experimental groups is equal to the mean of the control groups; which represents that there are no differences in the results obtained between the experimental and control groups after the didactic strategy for the application of statistical techniques from the PEA of the IAD subject in the training of the professional in Physical Culture was implemented. An alternative hypothesis (H_1) was posed: ($\mu_e \neq \mu_c$) the mean of the experimental groups is different from the mean of the control groups; which shows that there are changes in the results obtained between the experimental and control groups after the didactic strategy for the application of statistical techniques from the PEA of the IAD subject was implemented in the training of the professional in Physical Culture.

During the study, eight first-year groups from the CD (234 enrolled students) were worked with. The selection was structured randomly into four experimental groups (of 118 students) and four control groups (116 students). The groups were pre-formed. During the process, seven students dropped out (five from the experimental groups and two from the control groups), which is why results were obtained from only 227 students (113 students in experimental groups and 114 in control groups) of the total planned enrollment.

The main results obtained are shown by research groups, in Table 4 according to the ordinal scale assumed by Collazo (2016) (Table 4)

Table 4. - Evaluation of the indicators, dimensions and variables based on the frequencies calculated in the instruments applied during the quasi-experiment

Dimension 1: Reproductive assimilation level								
Indicators	Student Survey		Pedagogical test		Teacher Survey		Assessment	
	G. E	GC	G. E	GC	G. E	GC	G. E	GC
1.1	TO	B	TO	M	-	-	TO	B
1.2	TO	B	TO	M	-	-	TO	B
1.3	TO	M	TO	M	TO	M	TO	M
Dimension evaluation							Level 3 (A)	Level 1 (B)
Dimension 2: Productive assimilation level								
2.1	TO	B	TO	M	-	-	TO	B
2.2	M	B	M	B	-	-	M	B
2.3	M	B	TO	B	TO	B	TO	B
Dimension evaluation							Level 3 (A)	Level 1 (B)
Dimension 3: Creative assimilation level								
3.1	M	B	M	B	-	-	M	B
3.2	M	B	TO	M	-	-	M	B
3.3	M	B	M	B	TO	B	M	B
Dimension evaluation							Level 2 (M)	Level 1 (B)
Evaluation of the variable							Level 3 (A)	Level 1 (B)

In line with these results derived from the calculated frequencies, changes could be observed in indicators, dimensions, and in the variable between the experimental and control groups. From the evaluation process, it was obtained that, in the control groups, the three dimensions and the variable are at level 1 (B), which is reflected in 89% of the frequencies calculated by indicators. This makes it possible to evaluate the variable at level 1 (B), with undesirable results. In the case of the experimental groups, two of the three dimensions are at level 3 (A) and the remaining one at level 2 (M), all of which favors evaluating the variable at level 3 (A) with desired results.

To obtain greater reliability in these results, the non-parametric “Mann Whitney U” test was used. This test allowed to contrast the results from the initial calculation of the distribution function with a degree of significance of 0.1, although this value, among the three classified as universal, is the least popular due to the risk of committing type one error (Rodó, 2020), it is complemented by the large sample size, which increases the statistical power. With respect to the analysis to determine the significance of the changes in the study variable, it was possible to affirm that 95.2% of the calculated p-values are less than the 0.1 set for the degree of significance, in addition, a p-value = 0.01 was obtained for the variable. All this allows us to conclude that the null hypothesis ($H_0: \mu_e = \mu_c$) is rejected and the alternative ($H_1: \mu_e \neq \mu_c$), since there are differences in the results of each indicator between the experimental and control groups after the teaching strategy was implemented.

The quasi-experiment confirmed that the implementation of a focused, objective, reflective, contextualized, necessary, flexible, viable, and applicable teaching strategy revealed significant, positive changes in the variable application of statistical techniques from the PEA of the IAD subject in the training of professionals in Physical Culture.

The authors of this research recognized in the works of Pedroso et al. (2021), Castañeda et al. (2021, 2022, 2024), Linares et al. (2022), Pérez et al. (2023), Jorrín and Kessel (2024), coinciding elements that constituted supports, of a theoretical and methodological nature, for the application of Statistics from the development of the PEA. This conception provided a curricular support, becoming the development of some of the basic professional skills declared in the Study Plan "E" for the training of the professional. Jorrín et al. (2021) recognizes that statistical knowledge can contribute to the comprehensive training process of graduates. They also add that new methodological concepts should be promoted, characterized by the need to train students in the ability to analyze, model, and solve problems posed in different contexts. These criteria are agreed upon and further highlighted in the study carried out, respecting the teaching of Statistics through working with real data and aspects of statistical reasoning.

Conclusions

The research revealed the difficulties detected in the measurement of the dimensions and indicators that characterized the variable under study, based on the results of the instruments applied, which corroborated the existence of the problem and the need to find a solution.

The proposed teaching strategy integrates the structural components that ensure its functionality for the application of statistical techniques from the PEA of the IAD subject in the training of professionals in Physical Culture, while also revealing its relevance.

The implementation of the teaching strategy demonstrated a positive transformation in the studied variable. The implementation of the ATJ matrices, based on the criteria of a group of experts and the results of the quasi-experiment, confirmed that the proposed strategy meets the current demands of Cuban Higher Education, particularly those of the Manuel Fajardo University of Physical Culture and Sports Sciences.

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Abelardo López Domínguez: instrument development, general advice on the subject matter covered, review and final version of the article, correction of the article.

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