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Original article

Attitudes towards statistics among students of Computer Science

Actitudes hacia la estadística del alumnado de Ingeniería Informática

Atitudes em relação às estatísticas dos estudantes de Engenharia da Computação

Jorge Luis Mena Lorenzo[1]
https://orcid.org/0000-0003-1364-6524
Susana Roig Armas[1]
https://orcid.org/0000-0001-7690-0150
Juan Alberto Mena Lorenzo[2]
https://orcid.org/0000-0003-3695-9451
Carlos Luis Fernández Peña[2]
https://orcid.org/0000-0001-6833-0055

[1]Higher Polytechnic Institute "Gregório Semedo". Namibe, Angola.
jorgemenalorenzo@gmail.com; susanaroig1986@gmail.com
[2]University of Pinar del Río "Hermanos Saíz Montes de Oca". Pinar del Río, Cuba.
juanmenalorenzo1962@gmail.com; carlosl.fernandez@upr.edu.cu

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ABSTRACT

This study analyzes the significance of attitudes towards statistics in relation to gender, performance and academic year of students of Computer Engineering at the University of Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. Statistics is a fundamental tool in the training of computer engineers; however, attitudes towards this discipline can vary significantly among students, influencing their academic performance. This study seeks to delve deeper into this relationship and provide evidence that can guide pedagogical improvements. The main objective of the study was oriented to the analysis of the significance of attitudes towards statistics in relation to gender, performance and academic year of students of Computer Engineering at the University of Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. The methodology used was based on the comparative method and responded to a descriptive, correlational and cross-sectional research, in which the Estrada Scale of Attitudes Towards Statistics was administered. As a result, it was found that there are no statistically significant differences between the attitudes, gender and academic year of the students, but there are differences with their academic performance in the subject. It is concluded that, although gender and academic year do not significantly influence attitudes towards statistics, academic performance is related, suggesting the need for educational strategies that improve attitudes and, therefore, academic results.

Keywords: attitude; student; statistics; computer science; performance.

RESUMEN

El presente estudio analiza la significación de las actitudes hacia la estadística en relación con el

género, rendimiento y año académico del alumnado de Ingeniería Informática en la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. La estadística es una herramienta fundamental en la formación de ingenieros informáticos; sin embargo, las actitudes hacia esta disciplina pueden variar significativamente entre los estudiantes, influyendo en su rendimiento académico. Este estudio busca profundizar en esta relación y aportar evidencia que pueda guiar mejoras pedagógicas. El objetivo principal del estudio estuvo orientado al análisis de la significación de las actitudes hacia la estadística con relación al género, rendimiento y año académico del alumnado de Ingeniería Informática en la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. La metodología empleada tuvo como base el método comparado y respondió a una investigación descriptiva, correlacional y de corte transversal, en la que se administró la Escala de Actitudes hacia la Estadística de Estrada. Como resultado se obtuvo que no existen diferencias estadísticamente significativas entre las actitudes, el género y el año académico de los alumnos, pero sí con su rendimiento académico en la asignatura. Se concluye que, aunque género y año académico no influyen significativamente en las actitudes hacia la estadística, el rendimiento académico sí está relacionado, sugiriendo la necesidad de estrategias educativas que mejoren las actitudes y, por ende, los resultados académicos.

Palabras clave: actitud; estudiante; estadística; ingeniería informática; rendimiento.

RESUMO

O presente estudo analisa a importância das atitudes em relação às estatísticas em relação ao gênero, desempenho e ano letivo dos estudantes de Engenharia da Computação da Universidade de Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. A estatística é uma ferramenta fundamental na formação de engenheiros informáticos; No entanto, as atitudes em relação a esta disciplina podem variar significativamente entre os alunos, influenciando o seu desempenho acadêmico. Este estudo busca aprofundar essa relação e fornecer evidências que possam orientar melhorias pedagógicas. O objetivo principal do estudo foi orientado à análise da significância das atitudes em relação às estatísticas em relação ao gênero, desempenho e ano letivo dos estudantes de Engenharia da Computação da Universidade de Pinar del Río "Hermanos Saíz Montes de Oca", Cuba. A metodologia utilizada baseou-se no método comparativo e respondeu a uma pesquisa descritiva, correlacional e transversal, na qual foi administrada a Escala Estrada de Atitudes em relação à Estatística. Como resultado, obteve-se que não existem diferenças estatisticamente significativas entre as atitudes, género e ano letivo dos alunos, mas sim com o seu desempenho académico na disciplina. Conclui-se que, embora o género e o ano lectivo não influenciem significativamente as atitudes face às estatísticas, o desempenho académico está relacionado, sugerindo a necessidade de estratégias educativas que melhorem as atitudes e, portanto, os resultados académicos.

Palavras-chave: atitude; estudante; estatísticas; engenharia informática; desempenho.

INTRODUCTION

Statistics, as a data science, is part of the university curriculum and contributes to the development of professional thinking by providing scientific methods that favors the collection, organization, summary, presentation, analysis of data and obtaining valid conclusions. In addition, it promotes research and curricular development from sociocultural and educational foundations, constituting an important axis in professional culture.

As Barrera and Fernández (2022) state, statistics can be abstract, so it requires logical reasoning

and teaching that reduces the perception of difficulty that its learning generates (Acón and Salazar, 2020; Rodríguez and Gil, 2019).

In the unique case of Computer Engineering, statistics contributes through its content and methods to the formation of the logic of professional thinking and to preparation for employment. Once inserted in the company, professionals manage processes in the life cycle of computer systems, play roles in multidisciplinary teams and manage the automatic processing of the knowledge that is produced.

From the previous fact, it is understandable that the Cuban Computer Engineer Model has a strong component of statistical education, as a way to nourish the logic of their professional thinking. Statistical studies begin at the primary level of schooling, with a curricular ascent that impacts the entrance exams to Higher Education. Such an intention has broad support in Ibero-American universities that find in the study of Attitudes towards Statistics (AE) (Loayza, 2021) a solution to enhance professional training.

The EAs provide interesting keys for a more comprehensive analysis of statistical teaching and learning. However, the dichotomy in the definition of the object limits the analysis in this field. Being considered as a system of tendencies inferred from an early age, it influences the way students act professionally, and their aversion to these contents in later years (Aguilera and Perales, 2019).

Various questionnaires have been validated worldwide to measure this. Among the most widely recognized are the *Statistics Attitude Survey,* the *Attitudes Towards Statistics Scale,* the *Survey of Attitudes Towards Statistics* and the Scale of Attitudes Towards Statistics (EAEE) by Estrada *et al.* (2004).

This research is intended for the application of the EAEE, because it is written and validated in Spanish; it has excellent studies evaluating the psychometric properties of each item, with a validity and reliability of the scale assured, with reports of Cronbach's alpha values of 0.83, 0.84, 0.88 for pretest and posttest; and it is the one that best fits the features of the professional training of the Cuban Computer Engineer. In accordance with what has been stated, Comas *et al.* (2017) distinguish two components: one pedagogical, oriented towards the cognitive, affective and behavioral or tendency dimensions; and one anthropological, which has the social, instrumental and educational dimensions.

Other research studies the empirical relationships of statistical significance between AE and the gender of the students, and based on performance and academic year (Mello and Hernández, 2019).

This research is part of these lines of thought and recognizes the lack of empirical studies that explicitly and intentionally address the topic of AE in Cuba, from the specific didactics of this discipline, which highlights its current relevance.

The criteria allowed to guide the general objective of this study: to analyze the significance of the AE in relation to gender, performance and academic year of the students of Computer Engineering at the "Hermanos Saíz Montes de Oca" University of Pinar del Río, Cuba.

MATERIALS AND METHODS

The methodology used was based on the comparative method and responded to a descriptive, correlational and cross-sectional research, in which the Scale of Attitudes towards Statistics was administered.

The chosen population corresponds to the 73 (100%) Computer Engineering students in the 2019-2020 academic year, the majority being men (69.86%), as is traditional in this career (Table 1).

Table 1- Frequency distribution of Computer Engineering students (N = 73)

Academic year	Women		Men		Global Index	
	N	f 0 (%)	N	f 0 (%)	N	f0 (%)
First	8	10.96	17	23.29	25	34.25
Second	5	6.85	10	13.70	15	20.55
Third	5	6.85	7	9.59	12	16.44
Fourth	1	1.37	12	16.44	13	17.81
Fifth	3	4.11	5	6.85	8	10.96
Global Index	22	30.14	51	69.86	73	100

The questionnaire was administered by the teachers of each academic year and by the Statistics teachers of the Mathematics Department of the University of Pinar del Río, with the activity being correctly oriented so that the items were answered in their entirety. The answers to the questionnaire took about 15 minutes. The negative questions of the EAEE (2002) received a reverse grade. In this way, the total score is the sum of the answers to all the *items,* which allows avoiding the problem of acquiescence, since some subjects tend to answer "in agreement", whatever the content of the question, without reasoning about the quality of their answer. A five-point Likert-type scale is used: 1- strongly disagree; 2- disagree; 3- indifference; 4- agree; 5- strongly agree. It was necessary to make slight adjustments to certain *items,* in order to contextualize them to the type of professional and the Cuban university context. In order to find information related to the historical academic performance of students in the subject, a table work was carried out in collaboration with the staff of the teaching secretariat of the Faculty of Technical Sciences, with prior authorization from the entity.

The data were integrated into an Excel sheet and then analyzed using the SPSS statistical package, in its current version 27.0.

RESULTS

Figure 1 shows the mean scores (Mean) and standard deviations (Standard Deviation) corresponding to the two components (pedagogical and anthropological) and to the dimensions that structure them in the form of functional invariants. To obtain the graph, and with the aim of establishing more objective and integrative inferences, a double contingency table was constructed that allowed obtaining the intersection of the dimensions.

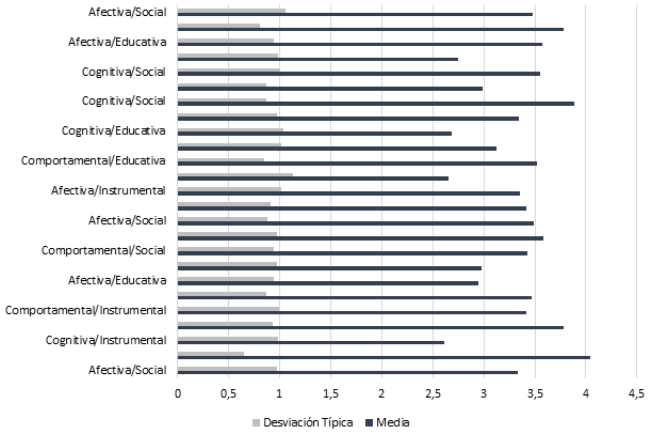

Fig. 1- Graphical representation of the mean scores and standard deviations obtained

It should be noted that the highest percentage of dimensions was around three points on the scale of values (92%), which means that an attitude of indifference prevailed, with a slight inclination towards the recognition of this discipline for the training of professionals. However, this slight result does not improve the perception that they have of statistics that serve to manipulate reality, and of boring classes in which problems of daily life and professional life are not solved. Paradoxically, students recognize the usefulness of statistics for professional decision-making.

The highest percentage of dimensions corresponds to a standard deviation, in line with the incorrect or low perception of students regarding statistics, evidenced by very different and variable responses.

Figure 2 represents the concentration of responses in each component of the EAEE.

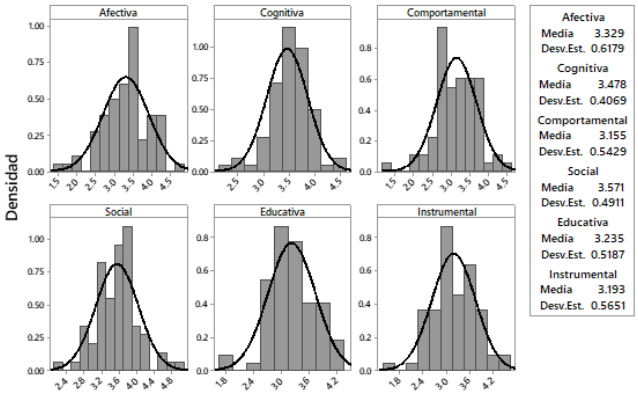

Fig. 2- Representation of student responses based on each dimension

The mean and median calculated as a measure of central tendency confirm in the graphs that the highest points are concentrated around the indifferent category. This is valuable information for the teaching staff, useful for modifying the perception of Computer Science students towards the learning of statistical content and methods.

As it can be seen, the most highly valued components are the social and cognitive ones; the rest of the components have very little differentiated scores. This indicates that the students consider themselves to have a certain capacity to learn the subject and recognize the social importance of statistics for any citizen.

With the scores obtained, the linear correlation between the components of the EAEE was determined, based on the Pearson correlation coefficient (r*)*, the bilateral significance [Sig. (Bilateral)], and the coefficient of determination for the variance of common factors (r^2), as illustrated in table 2.

Table 2- Correlations between the components of the EAEE

Correlations among the components of the EAEE							
		Affective	**Cognitive**	**Behavioral**	**Social**	**Educational**	**Instrumental**
Affective	*r*	1	.634 **	.647 **	.754 **	.793 **	.893 **
	Say. (bilateral)		.000	.000	.000	.000	.000
	r 2		.402	.419	.568	.629	.797
Cognitive	*r*		1	.509 **	.636 **	.783 **	.653 **
	Say. (bilateral)			.000	.000	.000	.000
	r 2			.259	.404	.613	.426
Behavioral	*r*			1	.716 **	.754 **	.690 **
	Say. (bilateral)				.000	.000	.000
	r 2				.513	.568	.476
Social	*r*				1	.603 **	.600 **
	Say. (bilateral)					.000	.000
	r 2					.364	.36
Educational	*r*					1	.725 **
	Next (bilateral)						.000
	r 2						.525
Instrumental	*r*						1
	Next (bilateral)						
	r 2						
** The correlation is significant at the 0.01 level (bilateral, in both directions between the variables)							

The results show that all correlations found between the components are significant at the 0.01 level, which indicates that the dimensions are directly associated. The correlations among the components are highly significant and of high intensity, demonstrating that each of these aspects can influence the others. In the case of the affective-instrumental correlation, it tends to be the highest; for example, the affection that one has towards statistics will influence the perceived usefulness of other subjects.

A higher than average percentage (53.3%) has a coefficient of determination (r^2) of less than 50%, which could indicate deficiencies in the components to explain the variations of its pair in the table. However, one should not think of a cause-effect relationship, since the coefficient r does not establish causal relationships. The affective-educational, affective -instrumental and cognitive-educational correlations show a coefficient r^2 greater than 60%.

Table 3, in its section *a,* shows the total number of women and men who completed the questionnaire with their respective means, standard deviation and error of the mean.

Section *b* indicates the results obtained by applying the Levene test to check the equality of variances and, depending on its result (equal variances: if p>0.05; different: if p<0.05), one of the variants of the *t* test is applied to check the equality of variance and equality of means between women and men, and thus evaluate whether the two genders differ from each other significantly with respect to the AE. The study took into account as null hypothesis (H_0) the equality of means for each variable ($\mu_M - \mu_H = \delta_0$) and, as alternative hypothesis (H_1), the difference in means for each variable ($\mu_M - \mu_H \neq \delta_0$).

Table 3- Results of the *t test* and its significance for the AE based on gender

Group statistics						
a	Gender	**N**	**Average**	**DT**	**Standard error of the mean**	
	Women	22	80.0	13.1	2.8	
	Men	51	84.5	10.6	1.5	
Independent samples test						
Levene's test for equality of variances				*t* test for equality of means		
		F	**Next.**	***t***	**gl**	**p-value**
b	Equal variances have been assumed	0.23	0.634	-1.55	71	0.127
	Equal variances have not been assumed			-1.42	33	0.165

In this sense, when applying the pretest to both groups (section *a* of table 3), it was possible to determine the equality of conditions and the non-existence of significant differences between them at the beginning of the study. The average of the students was 84.53 (n = 51) and that of the female students was 80.05 (n = 22). It can be interpreted that the men obtain a higher average than the women by a difference of 4.48 points. In section b of table 3, a p value of 0.127 is observed, which is greater than the coefficient á, accepting the null hypothesis. In effect, it can be stated that there are no significant differences between the genders with respect to the AE, showing that the groups are homogeneous.

The weighted standard deviation was calculated from the gender size (degrees of freedom denoted as: N_M and N_H) and their standard deviations (SD_M and SD_H), where M and H as subscripts mean women and men, respectively, obtaining a value of 11.37, representing the order in which the means vary with respect to each other.

Figure 3 presents the results obtained from the analysis of the relationship between the AE and the academic performance of men and women studying Computer Engineering. The quantitative evaluation in Cuban Higher Education is distributed in the following categories: 2.00 points (failed), 3.00 points (average); 4.00 points (good); 5.00 points (excellent). In addition, students are encouraged to take exams to improve their grades and award exams, with which they can achieve, according to a special regulation, an academic performance above 5 points. This process is intended to achieve a greater systematization of the students in the studies of each subject and, consequently, to improve the process of competent training of the professional.

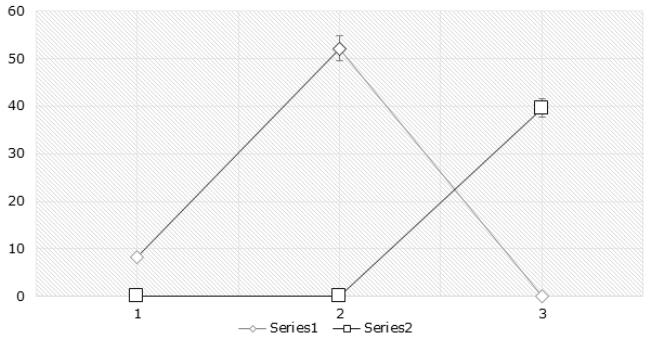

Fig. 3- Line graph for the association between AE and academic performance

As can be seen, the passing category predominates for academic performance, corresponding most frequently to students with indifference towards learning statistics, representing 52.10% of the total.

To complete the information obtained from the analysis using contingency tables and graphs, a

measure of association of variables was calculated, accompanied by its significance test. The test selected was Chi square, through which the existence of association between the categorical variables under analysis can be studied (Table 4).

Table 4- Results of the Chi square test for the association between the variables analyzed

Variables	Pearson Chi-square	*p*
AE* Academic performance	48,000 to	.000*
AE* Academic year	19.367 a	.080
* p <.05 a. 2 cells (33.3%) have an expected frequency less than 5. The minimum expected frequency is 1.58.		

A significant association is observed between the variables AE and academic performance ($p< .05$); that is, the Null Hypothesis (H_0) is rejected, which ensures, with a high level of significance, that academic performance is influenced by the AE. On the contrary, no significant association is found ($p > .05$) between the variables AE and academic year, which implies the acceptance of the hypothesis of independence between them.

DISCUSSION

As a starting point, various authors acknowledge that there is a lack of knowledge among teachers about AE and their negative impact on statistical learning, in particular, and on the training of professionals themselves, as a major concern (Navarro *et al.,* 2021).

Coinciding with Estrada *et al.* (2004):

> This negative attitude of teachers towards statistics could condition the teaching and have repercussions on the future attitudes of their students, so a deep motivation work will be necessary if we want the teaching of statistics to be a reality and not simply a wish expressed in the curricular guidelines (p. 264).

On the other hand, the mean scores and standard deviations obtained when applying the EAEE to the population under study showed that the students have an attitude of indifference with a slight inclination towards positivity. Other authors, such as Palacios *et al.* (2021), obtained similar results. In the case of Comas *et al.* (2017), the attitudes in general "were moderate or positive, with an overall average score slightly higher than the theoretical position of indifference" (p. 491).

The attitude of indifference towards statistics represents a pedagogical challenge for teachers; it is necessary, on the one hand, to involve students in the conscious study of professional content and, on the other, to modify their motivation towards learning. Indifference can be associated with confusion, personal insecurity and low self-esteem, experienced in academic activities without achieving the expected success.

The high significance and intensity shown in the correlations between the components of AE also reveal their potential to influence each other in a positive way. This would be an opportunity to reverse the indifference towards statistics, directing professional activities supported by the affective-instrumental dimension (with a higher percentage in the correlation), to boost development and enhance positive perception towards the subject.

Another of the specific objectives was aimed at determining the relationships of significance between AE and gender. The results obtained (Table 3, sections *a* and *b*) show that there are no significant differences between genders with respect to AE, which allows us to affirm that the groups are homogeneous.

These results are in line with the studies carried out by Escalante *et al.* (2012), in which no significant differences were found between genders in relation to EA. However, Comas *et al.*

(2017) found that EA is worse in Psychology students in the case of women. For their part, Bautista *et al.* (2016) found that women have a higher perception of usefulness than men, while anxiety and confidence levels are higher in men, which continues to make this relationship inconclusive and non-tendential.

Regarding the behavior of the AE and academic performance, a direct association was obtained between the students who selected the category of agreement, the dimensions of the EAEE and the notable category (performance between 4.00 and 4.55 points); and a higher percentage was found between the students with attitudes of indifference and the approved category (performance between 3.00 and 3.99 points); none is located in the outstanding category.

Similar results were obtained in research carried out in different countries, with different sample sizes, using different EA scales, and with students of different ages and training profiles. All of them confirm the average positive relationship between the grade in the statistics course and the attitudes towards this subject, considering them as a didactic alternative to predict academic results. In some cases, these results were associated with factors such as anxiety, confidence, pleasure and motivation, considering that the high positive correlation found explains their direct influence on academic performance.

For their part, Juárez and Mata (2021) found that EAs are positively related to factors of liking, confidence, usefulness, and student achievement in statistics courses. Undoubtedly, the relationship among EA, self-efficacy, performance in statistics, and students' perceived ability in statistics may be correlated, so it is important to take them into account in the teaching of this subject, in order to improve academic performance.

The results obtained by calculating the Chi square confirm what was stated about the significant association between the EA and academic performance, but not for the association with the academic year. In the case of Comas *et al.* (2017), they found that the overall attitude towards statistics worsens with the years of study, possibly because they encounter difficulties with the complexity of its contents.

In conclusion, it is suggested that the topic studied is not yet exhausted. Teachers must be more involved in the processes of assimilating new experiences of students. Learning must be stable, long-lasting and functional, so that professionals in training solve problems that are increasingly close to their work experience and enjoy the act of building their own knowledge, with the mediating help of teachers.

In this sense, the correlation between the EAs, the gender of the students, the performance and the academic year leaves theoretical and experimental gaps yet to be explored. Above all, in the order of systematization and continuity in the curriculum of statistical content as professional content for computer science, where the EAs are distinguished as functional invariants during teaching-learning. In another order of importance, it would be necessary to determine the contribution of the EAs to the formation of professional culture and identity from a development perspective and, finally, to discover how much these attitudes contribute to the adequate transition of the professional through each training cycle of the career.

The application of the EAEE in the Computer Engineering students of the University of Pinar del Río "Hermanos Saíz Montes de Oca" allowed building the taxonomy of the AE by gender and academic year; in addition, it promoted the debate among the students in relation to the accumulated grades in the subject. These results were presented to the teaching staff of the degree, providing a valuable resource to make the teaching of statistics a more inclusive, equitable and predictive process, as advocated by Sustainable Development Goal # 4 of the 2030 Agenda and, in equal proportion, to ensure the success and avoid the failure of the students in the subject.

Finally, it is acknowledged that this line of research leaves open different perspectives in relation to potential studies on motivational variables related to STEM studies, which could explain academic dropout in this type of career and the negative influence of statistics teaching practices, which distance its conscious learning as part of the professional content of every competent engineer in training.

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The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.

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