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PALMA (SPAIN)
3RD-5TH OF JULY, 2023

CONFERENCE PROCEEDINGS

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THE MEDIATING EFFECT OF ATTITUDES TOWARDS STATISTICS AND TECHNOLOGY IN UNIVERSITY STUDENTS

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Abstract

University students, especially those who study Social Sciences and Humanities, tend to express their fear at the beginning of classes in curricular units in Statistics, foreseeing possible difficulties in their learning. To evaluate and monitor the performance of students in Statistics course units, it is of utmost relevance that teachers and researchers consider some non-cognitive factors related to the students, such as the anxiety revealed in evaluation periods and the attitudes that students have in relation to Statistics and the use of Technology in these curricular units. In a post-pandemic period, the objective of this study is to investigate the interrelationships between some constructs and the potential mediating effect of attitudes towards Statistics and Technology on the relationship between anxiety and students' performance in these curricular units.

The data was obtained through the questionnaire containing variables of sample characterization, seven items concerned the Anxiety dimension of the Depression Anxiety Stress Scale (Lovibond & Lovibond, 1995), 28 items of the Students' Attitudes toward Statistics and Technology Scale (Anastasiadou, 2011) and, also, the variable referring to the performance of students in Statistics, operationalized based on the classifications obtained within the scope of the respective curricular unit in the area of Statistics. Higher scores in the Anxiety dimension correspond to higher levels of student anxiety. Students' Attitudes Toward Statistics and Technology Scale allows identifying the positive/negative attitudes associated with lived experiences in the context of learning Statistics with the use of Technology.

In this study, 274 university students participated, with the purpose of investigating the effect of the mediation of attitudes related to Statistics and Technology in the relationship between anxiety in assessment periods (independent variable) and performance (dependent variable). A path analysis was used, verifying which paths were supported by the data and what kind of effects (direct and indirect) explain the association between the variables.

In terms of data analysis procedures, a descriptive analysis, and the evaluation of the internal consistency of the items of the instruments used were carried out, based on Cronbach's Alpha coefficient. To test the mediation hypothesis, the Process macro (Hayes, 2021) was used, with the decision on the significance of the indirect effect based on the bootstrap estimation. The potential mediating effect of attitudes towards Statistics and Technology on the relationship between anxiety and performance was verified, that is, the indirect effect was statistically significant. It was also found that: anxiety was negatively associated with attitudes towards Statistics and Technology; attitudes towards Statistics and Technology were positively associated with performance; and anxiety was negatively associated with performance (significant direct effects).

Keywords: attitudes towards statistics; technology, higher education students.

1 INTRODUCTION

In recent decades, combined with the generalized increase in information and communication technologies and the growing complexity of society, with the massive production of data, the need arose to treat these data and the information associated with them, to understand reality. Statistics is increasingly present in our daily lives and the increase in Statistical Literacy should be a priority, given that this is indispensable for us to exercise responsible and conscious citizenship. Having the ability to decode the information that is presented to us in the most diverse media, and to understand and/or criticize it in a reasoned way are skills of extreme importance in today's society. Kafadar [1] recalls a few situations where statistics made a real difference and reinforced the impact of this discipline on society.

More and more students are starting to become familiar with statistics, at the level of basic and secondary education, and many higher education courses offer curricular units in the area of statistics with the aim of enabling them to understand and critically evaluate the information in their daily lives, on a personal and professional level, and to make the most appropriate decisions [2-4].

The fear of statistics is highlighted by some students, mainly from the Social Sciences and Humanities courses, who believe that it is a very complicated area related to mathematics, probability, complex calculations and programs with statistical software. Past experiences and difficulties experienced can cause positive/negative attitudes and feelings even before starting a Statistics course unit [5] which are often automated responses over time [6]. The different attitudes on how students face Statistics is a factor of great importance to be properly studied [7-8].

According to Baloğlu [9], previous academic experiences indicate the student's academic background in statistics. Students with less previous mathematical experience seem to have more statistics anxiety. Attitudes towards statistics are related to the amount of anxiety that students experience, and in turn also to students' statistical performance. Attitudes towards statistics are the ideas and beliefs that someone has towards the subject of statistics. Chiesi and Primi [10] refer that negative attitudes towards statistics are related to a higher level of statistics anxiety.

Several studies have shown that a higher level of statistics anxiety seems to have a negative effect on performance in statistics, especially among social sciences students [11-12]. According to Onwuegbuzie (2004) [12], statistics anxiety can be defined as the feeling of worry that individuals experience when they encounter statistics mainly in evaluation periods.

It is important to investigate factors that play a role in the relationship between statistics anxiety and statistical performance, evaluated based on the classification obtained at the end of the semester for that curricular unit. As statistics anxiety seems to be related to statistical performance, statistics anxiety is related to attitudes towards Statistics and Technology and attitudes towards Statistics and Technology have impacts on statistical performance, attitudes towards Statistics and Technology may mediate the relationship between statistics anxiety and statistical performance on the other side. Therefore, it is very important to know whether attitudes towards Statistics and Technology (and their component dimensions) have significant impacts on the relationship between statistics anxiety and statistical performance [13-14].

The main objectives of this study are: to verify whether anxiety in evaluation periods has an influence on attitudes towards Statistics and Technology; investigate whether anxiety in assessment periods has an influence on academic performance; to determine whether attitudes towards Statistics and Technology have an influence on academic performance; and, finally, to find out whether the attitude towards Statistics and Technology plays a mediating role between anxiety in assessment periods and academic performance. Thus, the following research hypotheses were formulated:

H1: Anxiety in evaluation periods influences attitudes towards Statistics and Technology;

H2: Anxiety in assessment periods influences academic performance;

H3: Attitude towards Statistics and Technology influences academic performance;

H4: Attitude towards Statistics and Technology plays a mediating role between anxiety in assessment periods and academic performance.

2 METHODOLOGY

The data collection of the present study was done through a questionnaire. The survey was conducted on a sample of 247 students of a higher education institution in Portugal, encompassing students from different scientific areas.

Students are mostly female (69.3%), do not move from their usual place of residence (63.8%), attend courses in Social and Human Sciences (58.7%) and a large part attends the 1st year of course (46.7%). The age of students was between 17 and 57 years old, with a mean of 21.93 and a standard deviation of 6.38. Figure 1 illustrates the main sociodemographic and academic characteristics of the participants in the present study.

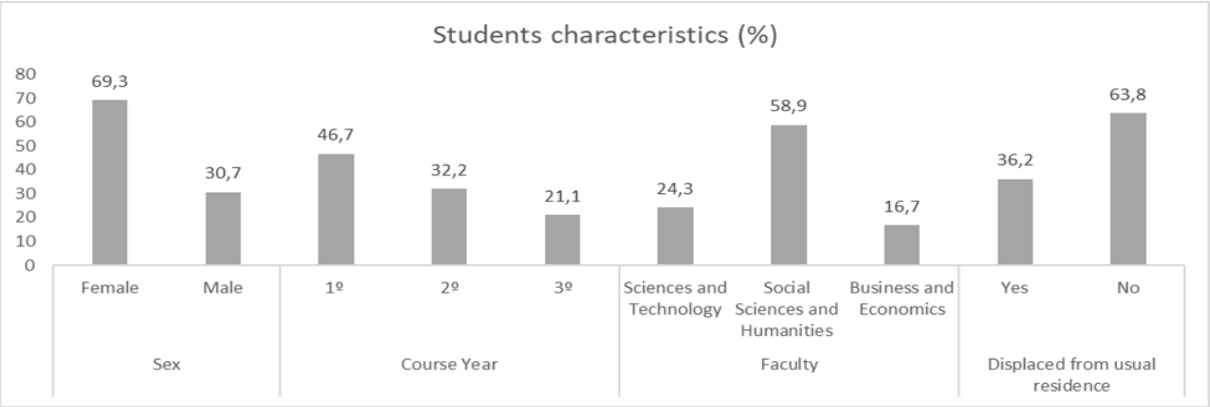

Figure 1. Sociodemographic and academic characteristics of the students of the sample

The questionnaire contains a scale composed of 28 items measured on a seven-point scale (1- totally disagree, 2- moderately disagree, 3- slightly disagree, 4- not agree nor disagree, 5- slightly agree, 6- moderately agree, 7- totally agree), in order to evaluate the latent variable assessed by the "Students' Attitudes toward Statistics and Technology Scale" (SASTSc) (see [15]). In this scale/construct, a higher total score indicates a more positive attitude. In the present research, the value of the Cronbach's alpha coefficient for this latent variable was 0.965, indicating a good internal consistency of the scale items.

The SASTSc [16] comprises five dimensions, namely: (i) Statistics Cognitive Competence or Cognitive Competence in Statistics (CCS) – positive and negative attitudes concerning a student's knowledge and skills as applied to statistics; (ii) Technology Cognitive Competence or Cognitive Competence in Technology (CCT) – positive and negative attitudes concerning a student's knowledge and skills as applied to technology – computers; (iii) Attitudes to learning statistics with technology (Tec) – positive and negative attitudes concerning the student's attitudes to learning Statistics with technology; (iv) Value (Value) – positive and negative attitudes to the worth and usefulness of statistics in students' personal and professional life; (v) Affect (Affect) - positive and negative emotions concerning Statistics.

The anxiety subscale of Depression Anxiety Stress Scales (DASS) of Lovibond and Lovibond [17] is composed of 7 items measured on a four-point scale (0-never, 1- sometimes, 2- often, 3- almost always). The items are as follows: A1- I feel tense or nervous; A2- I still enjoy the things I used to enjoy; A3- I have a feeling of fear; A4- I am able to laugh and see the fun side of things; A5- I have a head full of worries; A6- I feel excited; A7- I am able to sit comfortably and feel relaxed. A higher score indicates higher anxiety. In the present study, the value of Cronbach's alpha coefficient for this latent variable was 0.823, indicating a good internal consistency of the scale items. Academic performance was evaluated on a scale of 0 to 20 points in each curricular unit of Statistics that students attend in their course.

Then, the sum of the scores was calculated for both the 28 items referring to the attitude towards Statistics and Technology, as well as the 7 items associated with Anxiety. The normality test was carried out for these total scores and for the academic performance using the Lilliefors corrected Kolmogorov-Smirnov test, with the rejection of normality ($p<0.01$, in all cases). Therefore, we applied a non-parametric approach. Data were analyzed using several statistical methods, namely some summary measures, the Mann-Whitney U test (two independent samples, defined by the categories of the variable "Gender"), the Kruskal-Wallis test (more than 2 independent samples, defined by the categories of the variable "Course year"), the Spearman's correlation coefficient and the corresponding significance test, and the path analysis.

Spearman's correlation coefficient is a non-parametric alternative to Pearson's correlation coefficient. The values of this coefficient vary between -1 and +1, giving us information about the direction and intensity of the relationship between two variables at the level of the sample under study. In order to verify whether these results can be generalized to the population, the significance test associated with Spearman's correlation coefficient was used.

According to Baron and Kenny [18], to verify the mediation of variables, within the scope of path analysis, the following conditions must be met: i) the independent variable must explain the dependent variable; ii) the independent variable must explain the mediating variable; iii) the mediating variable must explain the dependent variable; iv) if the relationship between the independent variable and the dependent variable remains significant and unchanged after the inclusion of the mediating variable in the model under analysis, the mediation hypothesis must be rejected; v) if the relationship between the

independent variable and the dependent variable is reduced but remain significant after the inclusion of the mediating variable in the model, the hypothesis of partial mediation is supported; and vi) if the relationship between the independent variable and the dependent variable becomes non-significant after the inclusion of the mediating variable in the model, the hypothesis of total mediation is supported. To verify the mediation, the Sobel test [19] was also used to confirm whether the indirect effect is statistically significant or not, between the independent variable and the dependent variable through the mediating variable.

3 RESULTS

Table 1 presents a summary of results at a descriptive level (minimum value (Min), maximum value (Max), mean, standard deviation (SD) and median) concerning the total scores (sum of the scores of the items) for each of the constructs under study.

Table 1. Descriptive statistics concerning the total scores for each of the construct.

	Min	***Max***	***Mean***	***SD***	***Median***
Anxiety	1	21	8.62	4.49	8
Attitudes towards Statistics and Technology	28	196	128.33	32.91	133
Performance academic	1	19	11.5	2.94	12

Concerning the Anxiety, the total scores varied between 1 and 21 with an average value of 8.62. When the total scores are recoded into three categories, it can be considered that about 42.3% of the students manifest a low level of anxiety (between 1 and 7), 47.5% of these a medium level of anxiety (between 8 and 14) and about 10.2% of respondents a high level of anxiety.

Regarding the attitude towards statistics and technology, the scores varied between 28 and 196 with an average value of 128.33. Around 30% of the students of our sample have a negative attitude towards Statistics and Technology (between 28 and 112), and 70% have a positive attitude, of which around 22.6% have a very positive attitude towards Statistics and Technology.

Regarding academic performance in statistics curricular units, 84.3% of the participants obtained positive grades, while 15.7% did not achieve the desired success.

Using the Mann-Whitney U test (in the case of the groups defined by gender), it was found that for all dependent variables (Anxiety in assessment periods, Attitudes towards Statistics and Technology and Academic performance) there were no statistically significant differences between male and female students.

Using the Kruskal-Wallis test (in the case of the groups defined by the years of attendance), it was found that in the case of anxiety in evaluation periods there are statistical differences between students from at least two of the different years of the courses they attend ($H=6.274$, $p=0.043$). Applied the Dunn's test for multiple comparisons, between all pairs of groups, it is evident that the differences occur between 1st and 2nd year students ($p=0.028$) and 2nd and 3rd year students ($p=0.035$).

It was found that the correlations between the pairs of total scores corresponding to the variables under study are all statistically significant, namely: Anxiety regarding the evaluation periods and Attitude towards Statistics and Technology ($r_s=-0.313$; $p<0.001$); Anxiety regarding the evaluation periods and Academic performance ($r_s=-0.335$ $p<0.001$); Attitude towards Statistics and Technology and Academic performance ($r_s=0.936$ $p<0.001$). Thus, these results corroborate the following research hypotheses: Anxiety has negative effects on attitudes towards Statistics and Technology as well as on student performance; Attitudes towards Statistics and Technology have positive effects on students' performance, that is, the more positive their attitude towards Statistics, the better their performance in that curricular unit. Moreover, the hypotheses under investigation regarding the research model adopted in this work include Anxiety, the Attitude towards Statistics and Technology and their Academic performance, as shown in Figure 2.

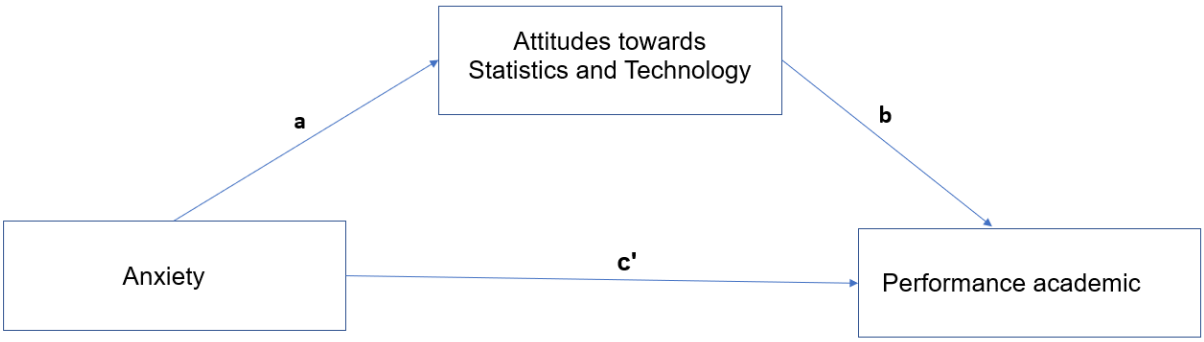

Figure 2. Mediation analysis

The potential mediating effect of attitude towards statistics and technology on the relationship between anxiety and performance was verified. The direct effect (**a**) reveals that Anxiety was negatively associated with Attitudes towards Statistics and Technology (**a**: β=-3.895; p<0.001). In the direct effects (**b**) and (**c'**), the Attitude towards Statistics and Technology and Anxiety are simultaneously included in the model. Attitude towards statistics and technology was positively associated with Academic performance (***b***: β = 0.080; p<0.001) and Anxiety was negatively associated with Academic performance (**c'**: β =-0.069; p<0.001). The total effect (**c**) of Anxiety on Academic performance (effect without considering the mediating variable in the model), showed a negative association (β =-0.380; p<0.001).

The indirect effect represents the portion of the relationship between the independent variable and the dependent variable that is mediated by a third variable. A bootstrapping confidence interval that does not include zero provides evidence of a significant mediating effect. In fact, when including the Attitude towards Statistics and Technology, as a mediating variable of the relationship between Anxiety and Academic performance, the indirect effect was significant (β =-0.311; 95% CI -.0.376; -0.238), indicating a mediating effect of this variable.

Table 2 presents, for all five dimensions (CCS, CCT, Tec, Value and Affect) components of the "Students' Attitudes toward Statistics and Technology Scale" (SASTSc), the results that show that there were significant effects, both in terms of the direct effect (**a**), where Anxiety has negative impacts in all these dimensions. On the other hand, all these dimensions revealed positive effects on Academic performance.

Table 2. Mediation analysis – Dimensions of "Students' Attitudes toward Statistics and Technology Scale"

	A - Anxiety	***B - Performance***	***Indirect effect of A on B***
CCS	β =-0.727; p=0.000	β =0.218; p=0.000	β =-0.159; IC: -0.214, -0.101
CCT	β =-0.453; p=0.000	β =0.453; p=0.000	β =-0.156; IC: -0.202, -0.102
Tec	β =-0.909; p=0.000	β =0.239; p=0.000	β =-0.217; IC: -0.276, -0.158
Value	β =-0.752; p=0.000	β =0.223; p=0.000	β =-0.168; IC: -0.238, -0.103
Affect	β =-1.054; p=0.000	β =0.226; p=0.000	β =-0.142; IC: -0.191, -0.093

All these dimensions (CCS, CCT, Tec, Value and Affect) associated with the Attitude towards Statistics and Technology turned out to be mediating variables, that is, there was a significant indirect effect between Anxiety and Academic performance. In fact, many of the difficulties faced by students in the domain of Statistics start right away in initial school education (e.g., [20]). Therefore, it is important to motivate the students in order to mitigate the effects of the anxiety.

4 CONCLUSIONS

The anxiety revealed by many students in Statistics curricular units should continue to be studied, in detail, to better understand its promoting factors and so that the strategies to be adopted are the most appropriate, in order to minimize it. We must also continue to focus on getting to know better the attitudes of students in relation to Statistics and Technology so that the strategies to be developed are promoters of greater proactivity and interest on the part of students. In this educational context, the professors who teach

Statistics curricular units have a major role in the interconnection of theory with practice, in order to motivate students to develop skills in the field of Statistics and to gain confidence in the art of data analysis.

In the present study, it was found that the anxiety manifested by students in evaluation periods has effects on the attitudes they have towards Statistics and Technology, as well as on their academic performance, which is among the several components of academic success. The higher the levels of anxiety revealed by students, the lower their academic performance tends to be, as well as the total scores obtained on the "Students' Attitudes toward Statistics and Technology Scale" (SASTSc).

The higher the total scores obtained in the SASTSc by the students, the higher their academic performance tends to be. Moreover, the variable "Students' Attitudes toward Statistics and Technology Scale" turns out to be a mediating variable between anxiety and academic performance, that is, the negative effect of anxiety on academic performance is mitigated through the intervention of the variable "Students' Attitudes toward Statistics and Technology". It should also be noted that the five dimensions of the SASTSc also proved to be mediating variables in the relationship between anxiety and academic performance.

It is extremely important that statistical literacy among society in general and students, in particular, continues to be duly valued, in order to promote an adequate learning of Statistics, which is essential for a better understanding of reality and for a more conscious performance in decision making.

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