A cross-sectional study on attitudes towards statistics in primary education students of Higher Education: prediction of variables through a multiple regression model

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ABSTRACT

The learning of statistics has been of high importance since the implementation of the European Higher Education Area (EHEA), and the new university degrees of the faculties of education in Spain have created curricula integrating subjects related to statistics and educational research. The subject is considered by most students to be difficult to learn, due not only to cognitive factors, but also to the attitude of the individual, a crucial factor in their learning. Therefore, the purposes of this study are: (1) to know the level of attitude regarding statistics of the future primary education teachers; and (2) to know what factors (gender, age, type of access to university, average admission score, frequency of class attendance, degree of involvement in work group) help to significantly predict these attitudes. For this, an ex post facto non-experimental design was implemented with a sample of 66 students from the primary education degree of the University of Almería (Spain). They completed an instrument based on attitudes towards statistics, which consisted of 16 items classified into three dimensions: negative emotional (threat, fear, tension); positive emotional (loving, liking, fun); and utility. Among the findings, the students exhibited an average level in the global attitude towards statistics. Regarding the global attitude, the results showed that the age of the students, the type of access to the university, the admission score, interest in the subject, and involvement in the work group influenced the attitudes of future students education teachers; while gender and class attendance did not show a significant influence. Further research is recommended to validate these preliminary findings in each of the instrument dimensions.

Keywords: statistics; primary education; higher education; attitude; students.

1. Introduction

Citizens of today's society are living through a number of continuous changes, being continuously exposed to digital and digitised data. Statistics are becoming increasingly interesting and essential for daily life. As explained by Slootmaeckers et al. (2014), Watson (2006), and West and Ficalora (2007), every person must have a basic knowledge of statistics in order to deal with the problems and events that can occur on a daily basis (for example, warnings of fraud or being cheated).

Particularly in the university and educational field, statistical research represents an important part of the training of future teachers in education, since the teacher of the 21st century must innovate and investigate new active methodologies to improve the learning of their students (Guillén-Gámez et al., 2020a). However, despite their importance, the level of these skills in higher education students is usually low (Astin et al., 2002; Asif et al., 2009; Cimpoeru & Roman, 2018). This problem translates into the presence of preconceptions and negative attitudes in students when taking statistical research subjects (Khavenson et al., 2012).

Faced with this conceptual framework, Phillip (2007) described attitudes as ways of acting, feeling, or thinking that display the disposition or opinion of a person. Estrada et al. (2011) point out that attitudes can involve negative or positive emotions arising from positive or negative experiences throughout the learning of a subject (in this case, statistics). However, other authors have added a new dimension to those that already exist, assigning great importance to the value Attitudes acquire in the personal or professional life of a student; that is, the utility or relevance in their daily life (Dauphinee et al., 1997).

Research on attitudes toward statistics in university populations of various specialties has gained strength in recent years (Guillén-Gámez et al., 2020b; Paul & Cunnington, 2017; Cladera et al., 2018; Chowdhury, 2018). For example, Mazana et al. (2019) studied the attitudes of 869 students towards learning mathematics in Tanzania, finding that, although initially they had a positive attitude, this decreased as their studies progressed to higher levels. On the other hand, Capuno et al. (2019) found that there was a significant, though weak, positive correlation between attitudes towards mathematics and the academic performance of 177 Filipino students.

In higher education, Cladera et al. (2019) evaluated the attitudes of 83 university students enrolled in tourism management studies. For this purpose, the anxiety, affect and self-confidence, and value associated with statistics were analysed. The results showed that students had positive attitudes about the affect and value of statistics in everyday life; however, negative attitudes were found in the anxiety dimension. With different results, Rejon-Guardia et al. (2019) analysed the attitudes of 526 university social science students according to gender. The results showed that, although students had positive attitudes in general, they did not express these in the difficulty and affect dimensions. In addition, significant differences were found in relation to gender, where females exhibited lower levels of attitudes compared to males. In

contrast, Coetzee and Merwe (2010) and Estrada et al. (2004) found no significant differences according to gender.

Aside from gender, other studies have focused on what demographic or academic factors may affect the development of attitudes towards statistics. Authors such as Mazana et al. (2019), Nguyen et al. (2016), and Macher et al. (2012) found that good academic performance significantly predicted students' attitudes towards mathematics and statistics. On the other hand, Ashaari et al. (2011) found that effort and interest in the subject significantly influenced positive attitudes towards statistics. Regarding the age variable, Coetzee and Merwe (2010) highlighted that older students perceived statistics as less difficult than younger students, and also identified slightly more positive feelings. Similar results were found by Stanisavljevic et al. (2014) regarding the significant effect of variables such as age and interest in the subject.

Taking into consideration the previous studies and the variables that have been analysed therein, we can distinguish two goals for the present study: (1) to determine the level of attitude towards statistics of primary education grade students; and (2) to analyse the relationship between the level of attitude towards statistics and different academic and personal variables that can predict and explain their level of attitude, in each of the dimensions of the instrument, as well as in the aggregate.

2. Method

2.1. Design and participants

A non-experimental survey design has been used. The participants were selected to obtain a non-probabilistic sample, with a total of 66 students of the primary education degree of the University of Almeria (Spain) during the academic year 2019–2020. Regarding gender, 45.5% (n= 30) were male students, while 54.5% (n= 36) were female students. The overall mean age was 19.41 years with a standard deviation of 2.54.

With regard to academic profile, 83.3% of participants accessed the educational degree through the baccalaureate, while 16.7% did so through a professional training cycle. Measured using a scale of 1 to 10, 81.8% of participants attended classes frequently, 57.6% were very interested in the subject, and 72.7% of the students said they felt very involved in their work groups.

2.2. *Instrument*

The SATS instrument (Survey of Attitudes Towards Statistics) was used, which was developed by Camacho et al. (2016). This instrument is composed of a total of 16 items across three dimensions: The negative emotional dimension is focused on attitudes towards statistics, whether students feel afraid, scared, or stressed by this type of learning, and is composed of 8 items (for example, the item SATS2 "*I feel insecure when I do statistical problems"*); the positive emotional dimension, focusing on the pleasure or fun that students may feel when learning this kind of content, and consists of 4 items (for example, the item SEA14 "*Statistics*

are pleasant and stimulating for me"); and, finally, the usefulness dimension, focused on students' perception of how useful their learning and practice is in real and meaningful contexts of this type of learning, and consists of 4 items (for example, the item SATS7 "*Statistics is a requirement in my training as a professional*"). To measure attitudes, a 5-point Likert scale was used, where the value 0 referred to "strongly disagree" and the value 5 to "strongly agree".

The instrument showed a very satisfactory reliability in each of the dimensions, as measured with Cronbach's alpha: negative emotional, $\alpha = 0.92$; positive emotional, $\alpha = 0.774$; utility, $\alpha = 0.745$; total dimensions, $\alpha = 0.90$. Regarding validity, exploratory factor analysis (EFA) explained 62.78% of the total variance of the true scores of the instrument, being 33.48% for the first dimension, 15.94% for the second, and 13.35% for the third. Confirmatory factor analysis (CFA) found that the internal structure of the instrument showed a good adjustment (χ^2=123.20; 101gl; p=.066, RMSEA=.024; CFI=NNFI=1; SRMR=.045) and significant saturations.

Table 1 shows the description of the different variables of the study and their values.

Table 1. *Description of variables*

Factors	Variable	Type	Measurement scale	Categories
VD	Negative attitudes Positive attitudes Utility Total instrument score	Qualitative	Ordinal	5-point Likert scale
VI	Sex	Qualitative	Nominal	0: Male 1: Female
	Age	Quantitative	Basis	Years
	Type of admission	Qualitative	Nominal	1: Through bachelor's degree 2: Through professional training
	Score of degree access	Quantitative	Basis	Score
	Interest in subject	Qualitative	Ordinal	10-point Likert scale
	Frequency of class attendance	Qualitative	Ordinal	10-point Likert scale

2.3. Data analysis procedure and techniques

The analysis of the data included several procedures, which are detailed below:

- First, a descriptive analysis of the level of attitude towards statistics in each of the dimensions of the instrument, as well as the total attitude.
- Multiple linear regression: The objective of this technique is to find the best model using the principle of parsimony (with the least number of significant variables explaining the highest percentage of an event occurring), which helps to predict the

relationship between different independent variables and a response variable (Y). The assumptions of the multiple linear regression were tested through: absence of multicollinearity, linearity, and independence of errors. For this study, four regressions were carried out (three for each dimension of the instrument, and one further regression considering the total attitude as measured by the instrument).

3. Analysis of results

3.1. Negative emotional dimension

Table 2 focuses on negative attitudes towards statistics, showing the mean and standard deviation of each of the items. It can be seen that the highest calculated mean was for the item "*I am not very good at statistics*" (M= 4.02 ± 1.00), followed by the item "*When I am faced with a statistics problem I feel unable to think clearly*" (M= 3.64 ± 1.20). In contrast, the item with the lowest negative attitudes was "*I am afraid of statistics*" (M=2.45 ± 1.01). The overall average of the dimension was slightly higher than the average value of the 5-point Likert scale (M= 3.25 ± 0.51), indicating that learning statistics causes students to be afraid, scared, or tense at a medium to high level.

Table 2. *Students' attitude towards the negative emotional dimension*

	M	Sd
EAE2 - I'm not very good at statistics	4.02	1.00
EAE12 When I'm faced with a statistical problem, I feel unable to think clearly	3.64	1.20
EAE17 - Working with statistics makes me very nervous	3.26	1.17
EAE18 - I get upset when I have to work on statistical problems	3.06	1.02
SATS2 - I feel unsafe when I do statistics	3.11	0.95
SATS6 - Statistics is a complicated subject	3.05	1.22
SATS11 - I'm frustrated with the statistics test	3.44	1.05
SATS21 - I'm afraid of statistics	2.45	1.01
Total dimension		

For the negative emotional dimension, the following assumptions were tested. In the assumption of linearity of relationship, the Figure 1 P-P plot of the typified remainders and the histogram of the residues allowed us to check the linear relationship between the variables of the model. In the assumption of error independence, the Durbin-Watson test (D.W. = 1.71) indicated error independence, since the value obtained was close to 2 (Chen, 2016). Regarding the assumption of absence of multicollinearity, Table 2 shows that tolerance values were greater than 0.5, and the VIF values were below 10, indicating non-collinearity (Chan, 2004; Ghani and Ahmad, 2010).

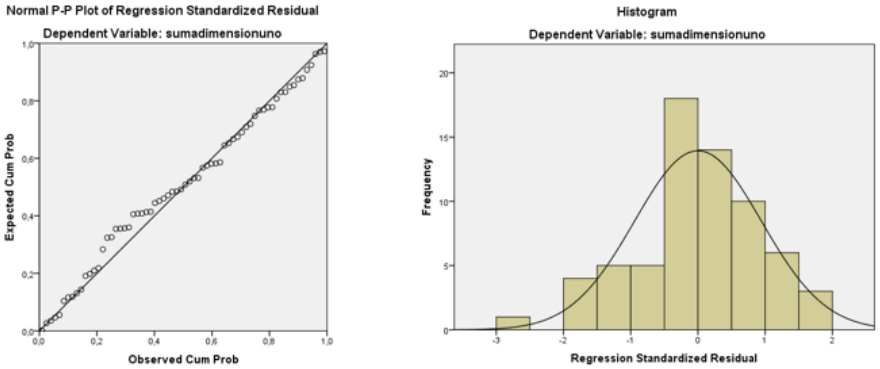

Figure 1. Histogram (left-hand side) and P-P graph of standardized residuals (right-hand side) for the negative emotional dimension.

The model proposed for the negative emotional dimension was significant, F (7, 58) = 6.931; p. < 0.05. The model with the significant variables explained 39% regarding the negative emotional variable (corrected R square = 0.39). The equation of the linear regression model with the standardized coefficients (table 3) can be seen below:

Y= 2.448 – 0.424* (age) – 0.279*(score of degree access)

The value of the constant (b= 2.488) indicates the value that we would assign to a student in the case other variables in the equation be equal to zero. In the case of age (b = -0.424), it indicates what would diminish the attitudes towards statistics of the student for each unit increase in age, when the rest of variables involved are kept constant. In the case of the average admission score (b= -0.279), being positive, this would increase the attitudes towards statistics for each point increase in the marks.

Table 3. *Model of regression in the negative emotional dimension*

	Unstandardized		Standardized			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	2.448	0.723		3.386	0.001		
Age	-0.085	0.025	-0.424	-3.348	0.001	0.585	1.710
Genre	-0.071	0.104	-0.070	-0.680	0.499	0.887	1.127
Admission to degree	0.306	0.162	0.227	1.888	0.064	0.650	1.538
Admission score	-0.095	0.037	-0.279	2.590	0.012	0.812	1.232
Class attendance	0.056	0.045	0.142	1.244	0.219	0.718	1.392
Interest in the subject	0.065	0.041	0.196	1.593	0.116	0.622	1.609
Involvement in the working group	0.032	0.031	0.122	1.016	0.314	0.651	1.537

3.2. Positive emotional dimension

Table 4 focuses on positive attitudes towards statistics. It can be seen that the item with the highest average was "*I would like to have an occupation in which I have to use statistics*" (M=

2.38 ± 0.94), followed by the item "*I enjoy talking to others about statistics*" (M= 2.36 ± 1.25). On the other hand, the item with the lowest average was "*Statistics are pleasant and stimulating for me*". (M= 1.61 ± 0.94). The general average for the positive attitude dimension was medium-low (M=2.11 ± 0.71). In comparison with the previous dimension (negative emotional), it can be seen that the students had a higher average of negative attitudes towards statistics than positive attitudes.

Table 4. *Attitude of the students towards the positive emotional dimension*

	M	Sd
EAE4 - Using statistics is fun for me	2.11	1.04
SEA9 - I enjoy talking to others about statistics	2.36	1.25
EAE14 - Statistics is enjoyable and stimulating to me	1.61	0.94
SEA19 - I would like to have an occupation in which I have to use statistics	2.38	0.94
Total dimension	2.11	0.71

Figure 2 supported the assumption of relational linearity between model variables. The Durbin-Watson test (D.W. = 2.27) indicated the independence of errors. Tolerance and PIV values were found in the permitted intervals, supporting the assumption of absence of multicollinearity.

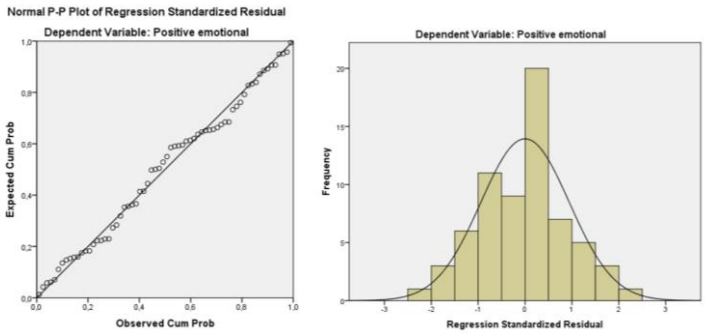

Figure 2. *Histogram (left-hand side) and P-P graph of standardized residuals (right-hand side) for the positive emotional dimension*

The model proposed for the positive emotional dimension was significant, F (7, 58) = 5.115; p. < 0.05. The model with the significant variables explained 30.7% of the positive emotional variable (corrected R square = 0.307). The equation of the linear regression model with the standardized coefficients can be seen below (Table 5).

Y= 4.502 + 0.380*(Admission score) + 0.307*(Involvement in the working group)

Table 5. *Model of regression for the negative emotional dimension*

	Unstandardized		Standardized			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF

(Constant)	4.502	1.083		4.157	0.000		
Age	-0.021	0.038	-0.076	-0.563	0.576	0.584	1.713
Gender	-0.258	0.154	-0.182	-1.674	0.100	0.906	1.104
Degree admission	0.381	0..242	0.201	1.573	0.121	0.651	1.537
Admission score	0.183	0.055	0.380	3.339	0.001	0.821	1.218
Class attendance	-0.057	0.068	-0.102	-0.835	0.407	0.718	1.392
Interest in the subject	-0.104	0.061	-0.222	-1.697	0.095	0.623	1.605
Involvement in the working group	0.112	0.047	0.307	2.408	0.019	0.655	1.527

3.3. Utility dimension

Table 6 focuses on students' attitudes about the usefulness of statistics in their future profession. It can be seen that the item with the highest average was "*Statistics are useless*" (M= 3.62 ± 1.03), followed by the item "*Statistics are not useful for the common professional*" (M= 3.56 ± 1.05). Regarding the item with the lowest average, this was "*In my profession I will not use statistics*" (M= 2.45 ± 0.98). In general terms, the students had an average attitude (positive and favourable) about the usefulness of statistics in their future profession, with a medium-high value (M= 3.01 ± 0.75).

Table 6. *Students' attitude towards the utility dimension*

	M	Sd
SATS5 - Statistics are useless	3.62	1.03
SATS7 - Statistics is a requirement in my training as a professional	2.61	1.11
SATS10 - Statistics are not useful for the average professional	3.56	1.05
SATS19 - I will not use statistics in my profession	2.45	0.98
Total dimension	3.06	0.75

Figure 3 supports the assumption of relational linearity between model variables. Durbin-Watson (D.W. = 1.97) tested the assumption of independence of errors. Tolerance and PIV values were found in the permitted intervals, supporting the assumption of absence of multicollinearity.

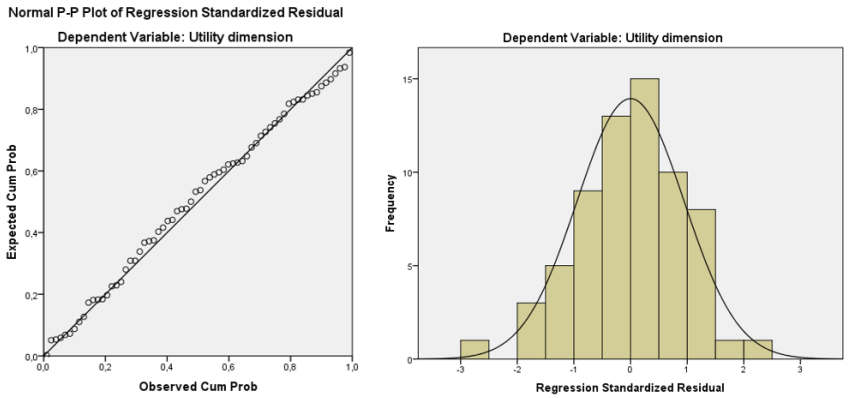

Figure 3. *Histogram (left-hand side) and P-P graph of standardized residuals (right-hand side) for the utility dimension*

The model proposed for the utility dimension was significant, F (7, 58) = 4.124; p. < 0.05. The model with the significant variables explained 25.20% of the utility variable (corrected R square = 0.252). The equation of the linear regression model with the standardized coefficients can be seen below (Table 5).

Y= 7,015 – 0.457*(Age) + 0.279*(degree admission) + 0.297*(admission score) + 0.110*(interest in subject)

Table 5. *Regression model for the utility dimension*

	Unstandardized		Standardized			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	7.015	1.190		5.896	0.000		
Age	-0.135	0.041	-0.457	-3.254	0.002	0.584	1.713
Gender	0.122	0.169	0.081	0.719	0.475	0.906	1.104
Degree admission	0.558	0.266	0.279	2.098	0.040	0.651	1.537
Admission score	0.151	0.060	0.297	2.510	0.015	0.821	1.218
Class attendance	0.078	0.074	0.132	1.042	0.302	0.718	1.392
Interest in the subject	-0.239	0.067	-0.483	-3.552	0.001	0.623	1.605
Involvement in the working group	0.043	0.051	0.110	0.833	0.408	0.655	1.527

3.4. Total Attitude towards statistics

The students obtained an average value for the total attitude towards statistics (2.81 ± 0.37). Figure 4 supported the assumption of linearity of relationship between the model variables and the Durbin-Watson (D.W. = 1.97) statistic supported the assumption of error independence. The tolerance and PIV values supported the assumption of absence of multicollinearity.

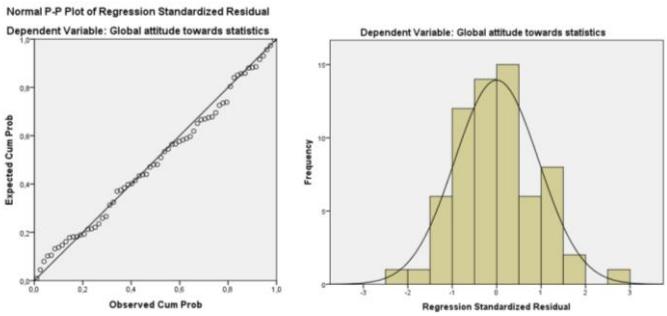

Figure 4. *Histogram (left-hand side) and P-P graph of standardized residuals (right-hand side) for global attitude towards statistics*

The proposed model was significant when considering all three dimensions of the instrument, F (7, 58) = 6,748; p. < 0.05. The model with the significant variables explained 38.2% of the total variance in the global attitude towards statistics (corrected R-square = 0.382). The equation of the linear regression model with the standardized coefficients can be seen below (Table 5).

Y= 4,641 – 0.588*(Age) + 0.424*(access to educational degree) – 0.325*(admission score) + 0.386*(interest in subject) + 0.336*(involvement in work group)

Table 6. *Model of regression for the global attitude towards statistics*

	Unstandardized		Standardized			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	4.641	0.527		8.809	0.001		
Age	-0.080	0.018	-0.558	-4.371	0.001	0.584	1.713
Gender	-0.056	0.075	-0.077	-0.749	0.457	0.906	1.104
Degree admission	0.413	0.118	0.424	3.507	0.001	0.651	1.537
Admission score	0.080	0.027	0.325	3.021	0.004	0.821	1.218
Class attendance	0.026	0.033	0.091	0.789	0.433	0.718	1.392
Interest in the subject	0.093	0.030	0.386	3.123	0.003	0.623	1.605
Involvement in the working group	0.063	0.023	0.336	2.789	0.007	0.655	1.527

4. Conclusions and discussion

The present research aimed to achieve two goals: to determine the level of attitude towards statistics of students in the university grade of primary education; and to identify the predictive variables for student attitudes.

The results presented in the previous section show that students displayed a negative attitude towards statistics at a medium-high level, evidencing the anxiety or tension they feel about learning in this area, echoing the findings of Khavenson et al. (2012) and Cladera et al. (2019). By contrast, the results for the positive emotional dimension showed that, although the students had slightly positive attitudes, they did not feel totally comfortable with this learning, with a medium-low level attitude, corroborating the results of Mazana et al. (2019). Although these results are encouraging, the students are still not totally aware of the usefulness this subject could have in their field of study, with medium level attitude, suggesting that there is a direct relationship with the negative emotional dimension.

With regard to the effect of academic and demographic variables on students' attitudes towards statistics, in view of the results obtained, age and qualifications providing access to university appeared to be the most significant factors in almost all dimensions of the instrument, corroborating the results found by Coetzee and Merwe (2010), Stanisavljevic et al. (2014), and Capuno et al. (2019). With respect to gender differences, there were no significant discrepancies in student attitudes by gender, as was also found by Coetzee and Merwe (2010) and Estrada et al. (2004). Another significant variable in the present study was the involvement of the student in his or her work group, which suggests that the fact that they worked cooperatively, and shared information, doubts or opinions with colleagues, improved their attitudes towards statistics. In addition to involvement in the group, level of interest in the subject was also found to be significant (Ashaari et al., 2011; Stanisavljevic et al., 2014), highlighting the need for teachers to engage students in this type of learning.

Although attitudes towards statistics were not entirely unfavourable, more effort is needed to search for new innovative and attractive strategies for teaching statistics. Therefore, it is necessary for teachers to strengthen their creativity and use of innovative methodologies such as Flipped Classroom, cooperative work, and gamification (Guillén-Gámez, 2020a) so that their students can understand the importance of this discipline in their professional and personal careers (Dauphinee et al., 1997; Slootmaeckers et al., 2014).

In regard to future studies and applications in this field, it would be interesting to not only increase the sample size in order to generalize the power of the results, but also to carry out a longitudinal study during the four years of the educational degree in order to determine whether there is a significant variation in students' attitudes towards statistics over time. Furthermore, this study could be applied to the degree of Social Education, since the application of statistics is quite relevant to this field. All of this will open up a pathway to study the attitudes of future primary education teachers in the field of statistics, which should be continued in future research, since the subject has not been investigated in sufficient depth.

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