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Assessment of monitoring in the teacher's function: A statistical study in engineering classes in a university of the state of Rio Grande do Sul, Brazil

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***Abstract*— *Monitoring is understood as a teaching modality that enhances the learning of university students. This work aims to analyze the average of the final grades of students of the Cartographic and Surveying Engineering undergraduate course in four cases: with three monitoring schedules, with two monitoring, with one monitoring and without monitoring; thus, verifying the occurrence of improvement in students' learning according to their final average grade. The students' means were analyzed by analysis of variance (ANOVA) and were compared using the Tukey´s test. 5% was considered as the level of significance. The statistical computational system R was used for all analyzes. We found that monitoring is of essential importance in the lives of academics, its inclusion provided an increase in the average grade of students in the Statistics and Probability component in the Cartographic and Surveying Engineering undergraduate course. We can say that monitoring is a factor that influences the average of students.*

I. INTRODUCTION

Monitoring is one of the programs to support teaching at the Federal University of Pampa (UNIPAMPA). The Undergraduate Monitoring Program aims to promote aid in the development of a discipline in order to support academic teaching and learning [1]. In addition, it is used as an important tool to assist in the development of academic activities, as well as providing positive experiences for student monitors and other university students [2].

In the statistical and probability curricular component, monitoring is an alternative for students to expand their knowledge using a more informal language.

Among the different ways of carrying out monitoring activities, we can mention the case where the monitor is present in classes, helping the teacher and students and reserving time for attending students [3].

More than the expansion of knowledge, monitoring is based on the construction of a future teacher, which encourages the monitors a brief statement of what it would be like to act in the teaching area. The monitor also helps in the personal growth of the student and to maintain responsibility, the attitude towards the final averages and the abundant study outside the classroom. In addition, monitoring can contribute to the construction of knowledge and evaluation processes [4,5]

Ethics is very comprehensive in monitoring. It requires exemplary behavior on the part of the monitor, remitting to his students characteristics that are equivalent to his professional life. Instigating a planning of activities for the students, making them obtain the desire for knowledge, researching and living experiences that result in softer knowledge, it is up to the teacher/coordinator of the monitoring project together trained students.

On the responsibility for the academic education of the other, from the moment the monitor understands his role, he transposes the view that he is solely responsible for his education, starting to occupy a prominent place by exercising a privileged function, full of possibilities for the education of the monitored and the monitor itself. It requires a commitment to this occupation, which includes, among other responsibilities, observing schedules and showing zeal for the learning of others [6].

Monitoring is hard and challenging work, but it motivates many other students to experience this, bringing new learning methods and teachings, experiences in academic life and an excellent relationship between teachers and students. This is often what is necessary for the training of new teachers for the teaching institution itself during their undergraduation.

The Monitoring Program emerges as a possibility to learn the complexity and ambiguity of teaching in the early years of training. In addition, monitoring enables a cooperative relationship between the teacher and the monitors, improving the learning of both [7].

We know that it is not a commitment to teach or learn, but to pass on knowledge and let students make their choices for what is best for them. And through this to be fully evaluated by the merits achieved during the monitoring period.

However, both roles are related, as paths cross in the teaching and learning process in which everyone in a certain way teaches and also learns, exchanges infinite coexistence leading to a constructive routine and maintaining an environment where teachers and students are in contact. the same level, which makes it irrelevant to consider that there is a high level among the participants.

The monitor is the one who helps in the training of the monitored and the one who learns from the monitored and the teacher. Monitoring is shown to be a tool that enables the fulfillment of one of the basic objectives of the learning process during under graduation, the process of learning to learn [8].

We can historically notice the structural growth of monitoring in the educational scenario. Federal Law No. 5,540 / 1968 implemented operating standards for higher education and designated academic monitoring. Article 41 says that universities should create monitoring activities for higher education students [9]. The National Education Guidelines and Bases Law provides in its article 84 that higher education students may be used in teaching and research tasks by the respective institutions, exercising monitoring functions, according to their performance and their study plan [10].

Given above, this work aims to investigate the monitoring effect on the final grades of undergraduate students in Cartographic and Surveying Engineering in four cases: three monitoring schedules offered to students in that discipline, two monitoring schedules, one monitoring schedule and no monitoring; thus, verifying the occurrence of improvement in students' learning according to their final average grade.

II. METHODOLOGY

We use the final averages of students from classes in the Statistics and Probability discipline of the Cartographic and Surveying Engineering (CSE) course at the Federal University of Pampa. For this purpose, grades from four classes were considered: A - class 2016/2 (28 students), B - 2017/1 (31 students), C - 2018/1 (38 students) and D - 2019/1 (29 students).

The students' average grades were analyzed by ANOVA (Analysis of Variance), whose model is given by

$$y_{ij} = \mu + \mu_i + \varepsilon_{ij} \qquad (1)$$

where y_{ij} is the average score of student j in class i, μ is a constant, μ_i is the effect of class i and ε_{ij} is the experimental error associated with student j in class i. The model in (1) assumes that the errors are identically distributed with a normal distribution of zero mean and constant variance, ie $\varepsilon_{ij} \sim N\left(0,\sigma^2\right)$. Still, in the model in (1), the inherent hypotheses of the model are:

$$\begin{cases} H_0 : \mu_A = \mu_B = \mu_C = \mu_D \\ H_1 : \text{at least one } \mu_i \text{ differs from the others (i=A,B,C,D)} \end{cases}$$

that is, the H_0 hypothesis is associated with equality between classes, so the average grade in the four classes is the same, which means that the monitoring did not provide differentiation between the average grades. In hypothesis H_1, there is at least one non-zero difference between the average grades of the classes. To test the null hypothesis (H_0) we must obtain the test statistic, which is given by the ratio of variances due to classes and due to random causalities (residual) [11]. Variations due to classes, also called sum squares of treatments (*SQTr*), and residual, also called sum squares of residuals (*SQR*) are calculated by:

$$SQTr = \sum_{i=1}^{I} n_i \left(\bar{y}_i - \bar{y}\right)^2 \qquad (2)$$

$$SQR = \sum_{i=1}^{I} \sum_{j=1}^{n_i} \left(y_{ij} - \bar{y}_i\right)^2, \qquad (3)$$

where y_{ij} is the average grade obtained by student *j* in class *i*, $\bar{y}_i$ is the average of class *i*, $\bar{y}$ is the general average, is the number of students in class *i* and *I* is the number of classes. The variances due to the classes, also called Mean Squares of treatment (*MSTr*), and Mean Squares of residuals (*MSR*) of the grades are, respectively,

$$MSTr = \frac{SQTr}{I-1} \qquad (4)$$

$$MSR = \frac{SQR}{I\left(n_i - 1\right)}. \qquad (5)$$

It can be shown that the ratio between equations (4) and (5) follows a Fisher–Snedecor distribution with parameters *I-1* and *n-I*, that is

$$F_c = \frac{MSTr}{MSR} : \; F_\alpha\left(I-1, n-I\right). \qquad (6)$$

Thus, to decide whether or not to reject the null hypothesis, the calculated statistic *Fc* is compared with the α-th quantile of the *F* distribution, that is, H_0 is rejected if $F_c > F_\alpha\left(I-1, n-I\right)$, where *n* is the total quantity of students. Alternatively, to decide whether to reject the null hypothesis or not, you can use the p-value. If the p-value is less than the level of significance, the null hypothesis must be rejected. More details can be seen in [12].

Therefore, we are interested in checking which of the averages are different from each other. For that, we used the Tukey´s multiple comparison test [13]. The difference between class averages is compared with the calculated critical value.

$$\Delta = q\sqrt{\frac{MSR}{2}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} \qquad (7)$$

where Δ is the critical value, *q* is the value of the total studentized range based on the Tukey distribution, n_i and n_j are the sample sizes *i* and *j* to be compared and *MSR* is the average square of the residual.

When the difference is less than or equal to the critical value, it means that the averages are different. For better evaluation of the results, different lower-case letters are used in different classes and the same classes will receive the same lower-case letters.

We used the Q–Q (quantile-quantile) plot to evaluate the model's assumptions in (1). The Q-Q plot consists of the points:

$$\left\{\left(F^{-1}\left(p_i\right), x_i\right), i = 1, \ldots, n\right\}, \qquad (8)$$

where $F^{-1}\left(p_i\right)$ is the inverse function of the quantile function of the Normal probability distribution, p_i are the percentiles and x_i are the data used to adjust the model, ordered in ascending order and n is the sample size (total number of students). The residues of the model in (1) have a Normal distribution if the points formed by the pair in (8) are close to a 45° line and are mostly contained in 95% confidence bands [14]. α = 5% was considered as the significance level for the tests, according to [15] and all analyzes were performed using the R Statistical Computational System [16] through the RStudio integrated interface [17] and the *agricolae* and *asbio* packages [18,19].

III. RESULTS

We can see that monitoring is a factor that influences the average of students. Through descriptive measures it can be seen that class C had greater amplitude and greater standard deviation, causing a high variability of the grades.

Table 1. Descriptive statistics of the four classes of statistics and probability of Cartographic and Surveying Engineering, UNIPAMPA-Campus Itaqui.

Descriptive statistics	Class			
	A - 2016/2	B - 2017/1	C - 2018/1	D - 2019/1
Sample size	28	31	38	29
Average	3.46	5.28	5.45	5.89
Median	2.95	6.08	6.01	6.31
Minimum	0.25	1.45	0.33	1.75
Maximum	7.55	8.76	9.43	10.00
Range	7.30	7.31	9.10	8.25
Standard deviation	2.23	2.34	2.39	2.32

While class A had less amplitude and less standard deviation, consequently the grades had very close values, with no variability. In class D, their final grade average approached the approval average established by UNIPAMPA, also reaching a maximum value in the final grade.

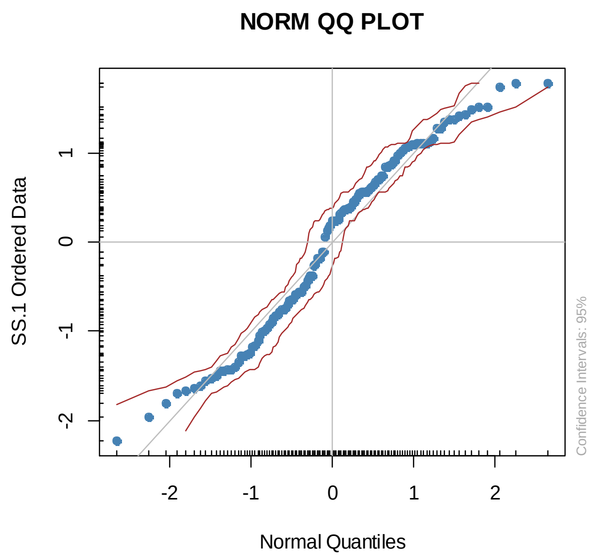

Fig. 1: Normal Q-Q plot of the ANOVA residues of the students' grades of the four classes evaluated in the statistics and probability classes at UNIPAMPA-Campus Itaqui.

We can see in figure 1 that the residuals of the ANOVA model are normal, since the ordered pairs formed by the theoretical quantiles of the standard and empirical normal distribution are close to a 45 ° line and are contained in the 95% confidence bands (red lines).

In order to verify the homogeneity of the class variances, the box-plot graph was used (Figure 2), where it is possible to verify the form of data distribution, in which the center of the distribution is indicated by the median line (in the center of the box), the top line is the third quantile of the data set and the bottom line is the value of the 1st quartile. As all classes have practically the same amplitude, difference between the 1st and 3rd quartiles, it can be said that the variances of the average grades of the classes are homogeneous. Thus, and in accordance with the results of figures 1 and 2, the ANOVA results are valid.

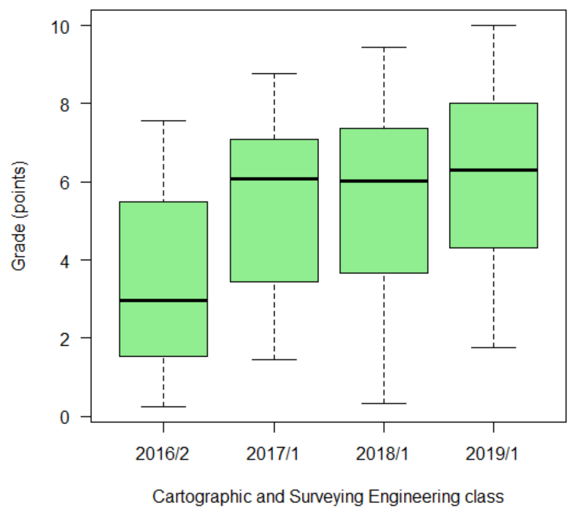

Fig. 2: Box-plot of students' grades in the four classes of statistics and probability classes at UNIPAMPA-Campus Itaqui.

In view of the results obtained, we can emphasize that the monitoring project is of paramount importance and fulfills its goals, as it brings returns to the teacher, to the monitors and is an alternative to the students, not only adding in their averages and academic history, but also in development within the educational institution.

Academic monitoring is recognized by teachers and students as a facilitating tool for achieving an effective teaching and learning process, both for those who exercise the function of monitor, supervised by a supervising teacher, and for the monitored, so that their knowledge and practices are strengthened [6].

In the dynamics of the relationship between the monitor and the monitored students, monitoring is more than a process instituted in the context of higher education, it is like a meeting point between apprentices, who identify themselves in the form of peers, under the understanding that the student's condition equals them, despite the monitor being in one or more academic periods ahead of the monitored. The literature brings some studies of situations that are beyond the reach of the monitor, such as the extra hours that the student spends to study a certain content, contents that the student is more familiar with and the time that he spends to complete an evaluation [20–22].

This conception emphasizes monitoring as a process that fosters learning, considering that the student supported by the monitor finds fertile space for clarifying doubts and consequent strengthening of skills, enhancing their knowledge with a lower degree of fear and in a more accessible way. This happens both in terms of maintaining contact, the language closest to and adapted to the student's reality, as well as the symmetries of their academic experiences, which differs from the student-teacher relationship, which is sometimes represented by fear, shyness and verticality on the part of the apprentice [6].

Table 2 - Table of analysis of variance (ANOVA) of the four classes in the statistics and probability classes of Cartographic and Surveying Engineering, UNIPAMPA-Campus Itaqui..

Variation Source	DF	SQ	MS	Fc	F	*p*-value
Groups (SQTr)	3	99.6	33.2	6.142	2.68	0.000634
Residual (SQR)	122	659.5	5.41	-	-	-
Total (SQT)	125	759.1	-	-	-	-

* DF: Degrees of freedom; SQTr: Sum Squares of treatment; SQR: Sum squares of residuals; SQT: Sum squares of total; MS: Mean square; Fc: Fisher-Snedecor critical quantile statistic: F: Fisher-Snedecor theorical critical quantile.

After carrying out the analysis of variance, we can see through the hypothesis test that at least one of the class averages is different, since the p-value test is less than 5% (Table 2). It is then necessary to perform the Tukey´s test to know which of the averages is different.

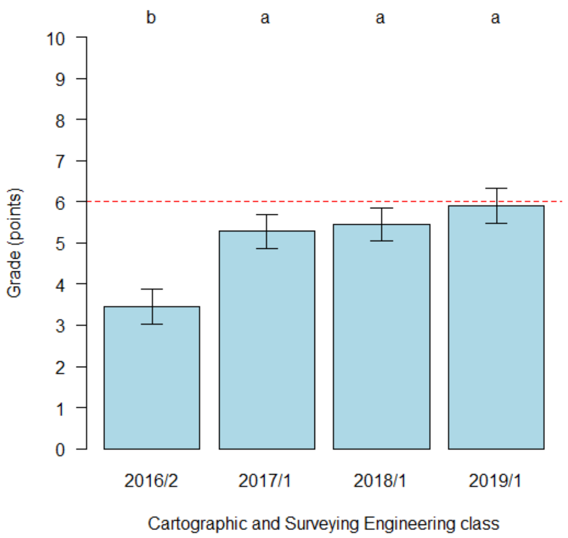

Fig. 3: Barplot of the averages of the four classes of the statistics and probability classes of the undergraduate Cartographic and Surveying Engineering, UNIPAMPA-Campus Itaqui.

Using the Tukey´s test [23] we analyzed that class A showed a difference between the others, while classes B, C and D are statistically equal and higher than the average grade of A. Although there is evidence that leads us to conclude that classes B, C and D differ from each other, when comparing their averages in table 1, neither one was significantly different.

Class A had a real average grade value significantly lower than the other classes. Considering all of this, the monitoring activity is seen as a space that promotes reflection, since different strategies are used to encourage students to review and deepen the curricular content worked in class. This practice was considered adequate to achieve better results at the end of the school semester.

Therefore, we can conclude that the presence of at least one monitor favors the class average to increase. Another observation: additional schedules / monitors do not provide a significant increase in the class average. It should be noted that the results are restricted to statistics classes in which the teacher provides lists of exercises to each class to students and the tests are given through open questions. Possibly, the result may be subject to change if the area of study were changed, for example, in human sciences area.

IV. CONCLUSION

We can conclude that there is a difference between the averages of classes A, B, C and D by the Tukey´s test. There is no difference between the average grades of classes B, C and D.

We can also state that monitoring is of paramount importance for all the people involved: monitor, teachers and students. 1) Because it is an experience for the monitor that can generate a future teaching career; 2) for the teacher, because he has someone to help him; 3) for students to have one more possibility to learn the content, to reinforce everything that is being taught by the teacher.

The program enables academic enrichment in the course area in addition to fostering interest in the teaching career of the student monitor, as the development of activities enables the skills and techniques of the teaching professional [24].

Monitoring practices are very important. They facilitate the learning process and help students to overcome problems, blocks, pressures, internalized difficulties that limit learning. The findings related to the characteristics of the monitoring emphasize the monitoring of students in their times, rhythms and advances, in personal and collective difficulties.

V. FINAL REMARKS

We understand, therefore, that the monitoring proposal is significant and is defined precisely in the way it is administered and in the commitment of those involved. Inadvertently, one might think that monitoring is an easy teaching modality; however, on the contrary, it is a demanding practice, which requires constant monitoring and care in the training and qualification of the monitors and a lot of effort by the guiding teachers. In Higher Education, taking on this pedagogical proposal can bring advances to student learning.

The work addresses the influence of the number of monitors in improving the students' average grade and other variables were not considered, such as the shift in which the students had the monitoring and classes, the socioeconomic conditions, among other variables. Very possibly, the average grade of a student is related to several other factors and several works in the literature address these characteristics [24–30]. We emphasize that the disciplines mentioned were taught by the same teacher in that discipline and the monitors involved had the same level of education and training to carry out the monitoring activities. However, it is known that different people with the same level of education can develop content in a more / less engaged way. Thus, we reinforce that our results should be interpreted with some caution when extrapolated to other disciplines in other areas, such as Humanities.

Thus, the monitoring program positively influences the Cartographic and Surveying Engineering undergraduate course, strengthening teaching and promoting interaction among the entire academic community.

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