Services Administration In Education. Utilizing Control Charts In Educational Management: An Approach For Assessing The Mathematics Scores In Panhellenic Examinations

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Abstract:

Background*: The choices offered to students and their parents complicate the process of finding an optimal solution that meets their needs, as competition increases[1]. The management of each educational organization is responsible for providing services information and curricula offered by the tutorials, as well as for designing innovative, cost-effective, and efficacious solutions[2].*

A learning organization with a student-oriented marketing approach is considered by many researchers as an effective mix to mixture that meets the needs of customers, students, and parents[3,4]. An organization with the above-mentioned features which apprehends its position, predicts the behavior of its customers, meets their needs and preferences, and enables marketing to be much more targeted and successful. As a result, it provides high-value services, which are its comparative advantage in the market[5].

The evaluation and intervention of education service providers and curriculum designers ensures the correction of errors and the adaptation to student and societal needs in all educational system processes. One of the most reliable statistical control tools of quality services and processes is the mean and standard deviation control charts[6]. Both respond to the requirements of in educational processes as they are described by the normal distribution.

Materials and Methods *In this work, the statistical tools have been utilized to analyze the mathematics scores in the economic and scientific studies orientation of the Panhellenic exams from 2003 to 2022[7]. The objective of this analysis is to investigate the application of control charts as statistical methods and identify the factors responsible for any out-of-control processes.*

Conclusion: *The study findings revealed that the modification of the curricula (all chapters of Algebra topics were removed, and only mathematical analysis topics remained) negatively affected the mean students' scores from 2015 to 2017, with a simultaneous reduction of variance. Distance education which was mandated due to the pandemic crisis did not negatively affect the mean values of the mathematics scores and increased the variance. A decrease in the number of the Panhellenic exams candidates is expected due to the demographic problem of Greece[8,9]. Moreover, extensive learning gaps for students who were in high school and elementary school during distance education are evident[10]. Finally, the service administration authorities in educational organizations and those who are responsible for the development of educational strategies should monitor student performance with the use of appropriate tools. This will help them to adapt their policies, educational tools, and curricula to the current conditions if it would be necessary.*

Keyword: *Services administration, Control Charts, Educational Services Providers Marketing, Math's Examination.*

I. Introduction

Efforts to manage an organization efficiently, in terms of processes, products, services, employees, customer and shareholder satisfaction[11] limiting unexpected changes, are a major concern of any service organization. Customers' expectations of the services they receive are determined by factors such as recommendations, personal needs, and their past experiences[12]. The relationship between service quality and customer satisfaction is closely intertwined. That is an improvement in one aspect is likely to result in a corresponding enhancement in the other[13,14]. Quality is considered as the mechanism for continuous improvement and promotion of service design and performance[15] based on measurements and facts[16] to gain the competitive advantage in the market[17,18].

The adoption of quality values in services is now a management theory based on three key principles: adding value for customers, creating sustainable growth and harnessing creativity and innovation[19]. Quality

management has moved into education as an effort to improve the quality of education, quality in classrooms and quality in the teaching process[20].

Educational organizations are constantly challenged to meet the increasing demands of their students and society, and as a result they have turned resorted to continuous improvement methodologies to make optimal use of available resources[21]. Competition between private schools, tutorial schools, private course delivery services, which are mainly private providers of the educational services for the student candidate's preparation for the Panhellenic exams, is has intensified. This That is accompanied by the increasing supply, the noticeable decrease in participants and the decrease in the country's student population, which make the modernization of the management methods, decision-making and educational processes imperative. The fathers of total quality management Crosby, Deming and Juran[22,23,24] highlight the benefits of this management philosophy in achieving quality results and excellence.

Continuous quality improvement plays a vital role in attaining and upholding exceptional standards of services and processes. This necessitates the achievement of measurable outcomes while minimizing variations. Statistical process control (SPC) is the application of statistical techniques that provide the necessary techniques and tools to solve various quality problems and achieve production stability by reducing undesirable variability. Inevitably, in any quality process, no matter how well designed or how carefully is maintained, a certain amount of inherent variability is always evident[25]. The main goal is to detect specific problem values and search for their causes early, so that corrective actions can be taken in time before the problem spreads. Considering the various SPC tools, the control chart (CC) is the most frequently used tool for identifying undesirable cases[6].

One of the key factors influencing the choice of a private secondary education provider, for both parents and students, is the performance of the institution's students in the Pan-Hellenic examinations[26]. In the present research, we examine the candidate's scores in the Panhellenic Examinations from 2003 to 2022 in the mathematics subject, which presents the lowest grades of all examined subjects. Our objective is to thoroughly investigate the underlying factors that contribute to these outcomes and present solutions. The research methodology is founded based on the theory of statistical process control, by employing control charts to monitor the mean and variance of the data.

II. Material And Methods

To ensure teaching quality and improve student learning[27,28], course performance assessment has become part of the educational process in many educational institutions, mainly in private ones. Statistical control of educational processes plays an important role in making important decisions about student retention, new enrollments, organizational visibility, and quality assurance in teaching and learning[29]. Despite the importance of evaluating the educational process, the way that is implemented remains a difficult issue. The main reasons are[30]:
1. Subjective interpretation. Everyone gives different interpretations of what is excellent, acceptable, or inadequate.

2. Unspecified evaluation methods such as comparing each observation to the average of all observations. Because the distribution of all observations is approximately normal, then approximately half of the observations are above the mean and the other half are below. So, comparing the observations to the average is of no use[31]. Another unwarranted but popular method is to use an arbitrary number (e.g., 4 on a five-point rating scale) to categorize educational processes.

3. Ignorance of uncontrollable factors affecting processes.

The theory of statistical process control, specifically the utilization of mean and standard deviation control charts, is recommended for the control of educational processes. To assess the Lyceum students' scores in the mathematics course in the Panhellenic exams from 2003 to 2022, which is the purpose of this research, mean and standard deviation control charts (part of the Six Sigma process) were selected[32,33].

The data represents the mathematics scores in the Panhellenic exams for the science studies orientation and the economic studies orientation. These scores are officially announced by the Ministry of Education of Greece on an annual basis, along with the announcement of each candidate's scores[7].

The curricula and school subjects that candidates of the Panhellenic examinations are tested on in the scientific studies and the economics studies orientations are common. However, the processing of the data and the mean and standard deviation calculations for each study orientation were carried out separately because the scores distributions of these 2 candidate groups are statistically significantly different, which is empirically and statistically established with the Kolmogorov- Smirnov test ($D_n=3.004$, $p<0.001$). The software used to calculate the means and standard deviations was Microsoft Excel, as the scores are grouped into classes of unequal width and do not facilitate their automatic calculation. Then, Minitab 18 was used to check the normality and distributions differences of the two orientation fields. The construction of the control charts was carried out using

Microsoft Excel. For the control charts construction of the mean score values x_i ($\bar{X}$ Control charts) of each year we followed this procedure:

Let x_i, i=2003, 2004, …, 2022 the mean scores for each year. The number of the examination years is $n = 15$, from 2003 to 2022 and the scores mean is: $\bar{x} = \frac{\sum_{i=2003}^{2022} x_i}{n}$.

The scores variance is: $s^2 = \frac{1}{n-1}\sum_{2003}^{2022}(x_i - \bar{x})^2$ while the scores standard deviation is $s = \sqrt{s^2}$. The control chart upper line is $UCL = \bar{x} + 3s$ while the control chart lower line is $LCL = \bar{x} - 3s$.

Finally, we consider whether the under-control process should satisfy the following conditions (Orme, J. G., & Cox, M. E., 2001).

There are no points outside the control limits.

There is an equal distribution of points on the 2 sides of the central line.

2/3 of the points are close to the central line.

Only a few points are close to the control limits.

There are no consecutive 4 or more points on one side of the center line.

There are no groups of consecutive points that show a trend towards one control limit or the other.

No evidence of straight line.

Procedure methodology

For the economics orientation and scientific orientation (4th field) we calculated the mean scores of each year, their average value, standard deviation, and control charts upper and lower limit.

The normal probability plot shows that the scores indeed follow a normal distribution. Even the Anderson Darling statistical test (AD=0.479, p=0.209>α=0.05) shows that the normal distribution hypothesis is not rejected.

Table no 1: Normal probability plot for the Economics studies orientation
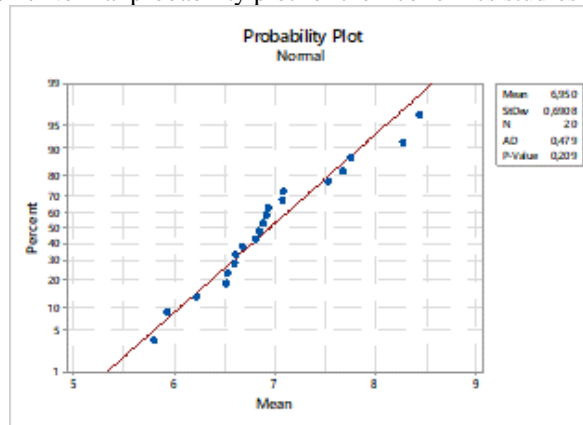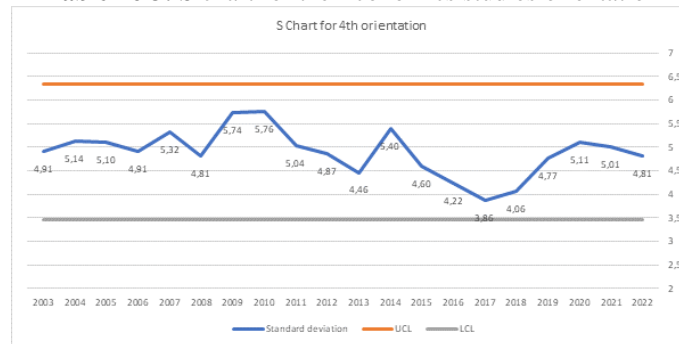

Moving on to the statistical control of the mean value and the standard deviation of the scores, the control charts are presented below:

Table no 2: $\bar{X}$ chart for the Economics studies orientation
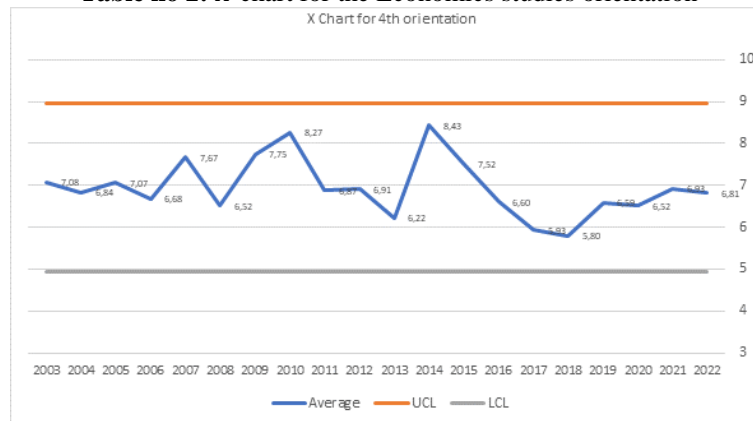
**Table no 3:** S chart for the Economics studies orientation

It has been observed that all values fall within the control limits and meet all the criteria we have established. It is worth mentioning that in 2014, the scores exhibited the highest average, but they also had the highest standard deviation, which can be considered marginally normal. From 2016 to 2018 the mean scores are constantly decreasing along with their standard deviations, which is due to the change in the school curriculum which now includes only mathematical analysis after the complex numbers chapter has been removed. Apparently, it took a reasonable amount of time for private organizations that prepare exam candidates, to produce new curricula and training material adapted to the new examination system. Of particular interest are the scores from 2020, which were obtained following the initial lockdown imposed due to the pandemic. During this period, schools were closed in March and reopened shortly before the May examinations. These scores hold significant importance and warrant closer examination. The mean scores value did not change and at the same time the variance decreased, which leads us to the conclusion that this temporary closure of schools and the transition to distance learning did not affect candidates. Even though the public schools' response to this emergency was delayed mainly due to technical obstacles, the immediate response to the digital transition of teaching by private educational service providers, private schools, tutorial schools and private lessons, gave the opportunity to their students, who participated in 2020 and 2021 in the Panhellenic exams, to take advantage of the above available time to their advantage[10]. In 2021, when most courses were conducted remotely, there was a noticeable improvement in both the mean and standard deviation of scores. This positive trend emerged after resolving most technical issues related to equipment and internet connections.

In the scientific orientation (2nd field), we have computed the average scores for each year, as well as their mean value, standard deviation, and the upper and lower limits of the control charts.

Testing the normality of the distribution with a probability plot, this shows us that the observations are normally distributed. Even the Anderson Darling statistical test (AD=0.68, p=0.064>α=0.05) shows that the normal distribution hypothesis is not rejected.

**Table no 4:** Normal probability plot for the Science studies orientation
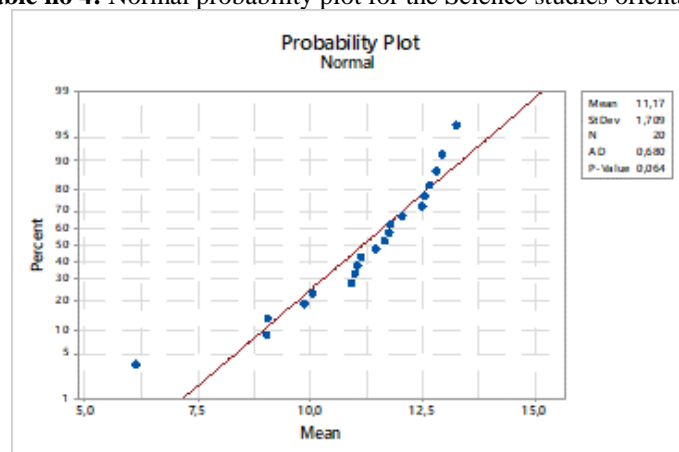
Based on the average score, our control charts indicate a variance study that reveals a value in 2016 exceeding the control limits of the $\bar{x}$ chart. However, it is important to note that the standard deviation for all observations remains within the limits of the diagram. In these examinations 76% of the candidates in the 2nd field had a score under 10 and 62.5% of the candidates under 5. It appears that the recent alteration in the school

curriculum, which now solely focuses on mathematical analysis chapters, has had a detrimental impact on the candidates' performance:

Table no 5: $\bar{X}$ chart for the Science studies orientation
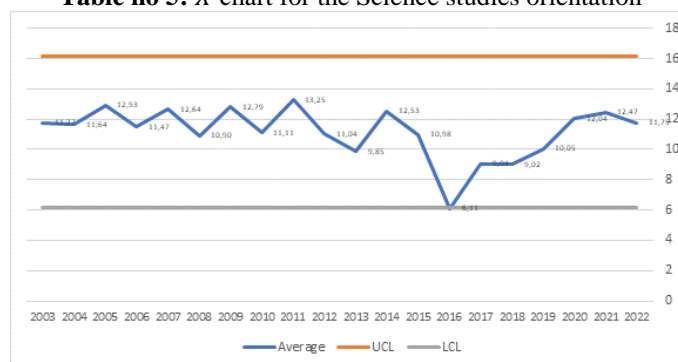
Table no 6: S chart for Science studies orientation
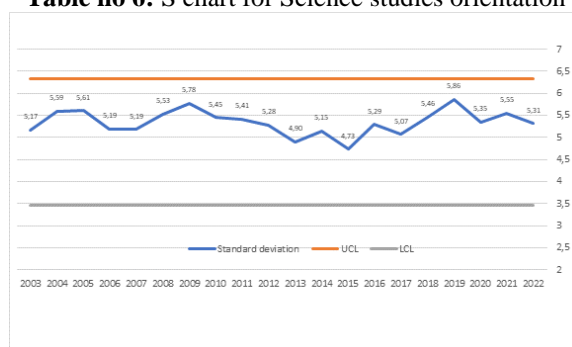
III. Discussion

As the number of students decreases and at the same time, private providers of secondary education services increase, the development of marketing strategies to retain students and enroll new ones, is imperative for the survival of any organization[2]. Among the most important criteria for selecting a private provider of secondary education services, for parents and students alike, are the organization's students' scores in the Pan-Hellenic examinations[26], which makes the statistical analysis of the students' performance in these exams a suitable comparison measure of their performance.

To ensure the quality of educational processes and enhance the services provided, it is highly recommended to utilize control charts, which are an integral component of statistical control theory. Statistical control is used in the quality control of both products and services[34], as it is a total quality management technique, and the necessary condition is that the data follow a normal distribution[35].

The data processed are the mathematics course grades of the Panhellenic examinations for the Economic studies orientation and the scientific studies orientation. These scores are announced annually by the Ministry of Education of Greece (minedu.gov.gr., 2022). The scores are normally distributed for both Economic studies orientation (AD=0.479, p=0.209>α=0.05) and scientific studies orientation (AD=0.68, p=0.064>α=0.05) Then, SPC was performed with the use of Control Charts for mean value and standard deviation.

The mean values for the 4th orientation are as follows: mean=6.95, standard deviation=0.67, UCL=8.97, LCL=4.93. It is worth noting that no score value was found to exceed these limits. In terms of variations, the mean is 4.89, with a standard deviation of 0.48. The UCL and LCL for variations are 6.33 and 3.45 respectively, and no value was found to fall outside these limits.

Moving on to the mean values of the 2nd orientation, we observe the following statistics: mean=11.17, standard deviation=1.66, UCL=16.16, LCL=6.17. Like the 4th orientation, no value was found to exceed the established limits. As for variations, the mean is 5.35, with a standard deviation of 0.28. The UCL and LCL for variations are 6.17 and 4.51 respectively, and no value was found to deviate from these limits.

The findings indicate that the scores were significantly influenced by the implementation of the revised school curriculum in 2016. Additionally, there was a slight impact from the financial crisis spanning from 2010 to 2018, as well as the introduction of distance education in 2020 as a response to the COVID-19 pandemic.

IV. Conclusion

For a more complete understanding of the students' performance in the Panhellenic examinations, we suggest a scores analysis for the rest of the courses in all fields, as well as the repetition of this research on a continuous basis to detect any problems in time and carry out the appropriate interventions. As a decrease in the number of the Panhellenic exams candidates is expected due to the demographic problem of Greece, extensive learning gaps for students who were in high school and elementary school during the distance education period are evident[1].

The implementation of quality-oriented strategies is crucial for an organization's long-term performance, achievement of objectives, product development, financial sustainability, overall well-being, marketing plan, and human resource management. Adopting such strategies is essential to ensure the organization's success and growth in a competitive market. Without a strategic quality plan, time, money, and effort will be wasted by the organization in dealing with problematic processes, defective products and services and customer complaints. Quality planning involves identifying both external customers and internal stakeholders within the organization and comprehending their needs. This process, commonly referred to as "listening to the voice of the customer (VOC)", aims to develop products or services that not only meet but surpass their expectations. The organization must establish a clear plan for the implementation of these products and services, ensuring a systematic and specific approach that enhances overall quality. This step is crucial and integral to the overall process[25].

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