



Using a Modified Quality Control Charts on Academic Grades of Tertiary Institutions Students

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Received on: October, 2023

Revised and Accepted on: November, 2023

Published on: December, 2023

ABSTRACT

Quality of products or services has different meaning by different Authors. Quality of academic processes in Nigeria is measured mainly by the standard set by regulatory bodies of Educational Institutions. There are a number of factors that affects quality assurance and students' academic performance in Nigeria. This study is on the application of statistical quality control techniques on the academic performance of students. The study was aimed to investigate the performance of both National Diploma (ND) and Higher National Diploma (HND) students of the Waziri Umaru Federal Polytechnic (WUFP) Birnin Kebbi, Nigeria, using a modified version of the Shewhart's quality control charts. Nine (9) departments from a total of 32 departments of the institution were selected. A total of 720 student's records of Cumulative Grade Point Averages (CGPAs) were studied. Twenty student's records each were selected per session and per programme. The results showed that the overall performance of students of the Institution is within the average standard expected of each graduand of the Polytechnic as provided by the regulatory body, the National Board for Technical Education (NBTE).

Key words: Quality control, X-bar, R-chart, CGPA, Students, NBTE.

1.0 INTRODUCTION

Education is a vehicle for national development and therefore, every effort has to be put in place to ensure proper teaching and learning activities in the school. However, students' academic performance has always been a concern and topic of interest for teachers and the society at large (Orji, 2019). In Nigeria, like in most countries of the world, tertiary institutions of learning are responsible for the training of students who successfully completed their Secondary school education. Young secondary school graduates secure admissions into tertiary institutions after satisfying a minimum entry requirement. After a prescribed period of time and undergone an academic program, the graduands of such programmes will be conferred or awarded certificates by the authority of the institution as having acquired the prerequisite training. Tertiary Institutions in Nigeria are saddled with the responsibility of training and producing middle and higher level manpower for the country (FRN, 2014). Tertiary Institutions in Nigeria ranges from Colleges of Technology, Colleges of Education, and Polytechnics to the Universities.

Graduands of tertiary Institutions are graded and certificates are awarded accordingly. There is no doubt that assessment of students is always a parameter through which quality of education can be reviewed (Furtado and Oliveira, 2018). The grading system is usually designed by the regulatory or supervisory body of each institution. Polytechnics in Nigeria are regulated and supervised by the National Board for Technical Education (NBTE). Final grade of student, otherwise known as the Cumulative Grade Point Average (CGPA), is used to determine the ability and quality of a graduand. Equally the CGPAs are used to identify the class of certificate to be issued to the deserving candidates.

Certificates in Nigerian Polytechnics are classified into four: Distinction, Upper Credit, Lower Credit and Pass (NBTE, 2004). This classification also explains and measure the level of quality and competence of a graduand. The mandate of the Polytechnics in Nigeria is to train both middle and high level manpower for the nation's economy (Polytechnics Act, 2019 as amended). In view of this, therefore, the Polytechnics awards National

Diploma (ND) and High National Diploma (HND) and in some cases also awards Bachelor's degree in Engineering or Technology. Both ND and HND programs are two (2) year (four semesters) duration each. Number of graduates produced by tertiary Institutions in Nigeria is on the increase with hundreds of thousands graduating annually (NBS, 2017). However, is not just about the number but the quality of these graduates. Adebayo (2015) argued that the engine room of sustainable transformation seems to be the graduates from tertiary institutions of any nation. Today, it seems there is complaint over these products on the question of quality to meet the labour market demand to transform the nation.

Quality Control (QC) may be defined as a system that is used to maintain a desired level of quality in a product or service (wisdom IT services, 2020). Quality has become one of the most important consumer decision factors in the selection among competing products and services (Montgomery, 2009). Giami and Peace (2020) opined that quality can also be seen as the ability with which a product, service or phenomenon conforms to an established standard and which makes it to be relatively superior to others. Similarly, Tarika and Gagan.(2021) added that, quality is one of the most important factors in education since the last few decades. Victor (2014) opined that in every process, quality of its outputs is determined by the quality of the inputs. SPC allows a contextualized, robust and unbiased analysis of the variability of quality indicators involved in the accreditation and monitoring processes, providing valuable information for decision making to administrators, teachers and other stakeholders (Ana, Eyda and Pilar (2022).

Ivana, Jiri and Marek, (2019), described quality assessment as a long process which establishes measurable student learning outcomes, then analyses and interprets them. A study conducted by Hanna, *et al.* (2012), showed that SPC is effective in demonstrating the need for standardization of course outcomes prior to efforts at continuous improvement. They added that SPC can be used in any improvement cycle particularly by academic administrators who seek to fulfil the mandates described by their supervisory or regulatory bodies. Acquisition of academic training is a process and

the output of such process is always in form of services rather than physical products. The Polytechnic training is a process which takes between two to five years, therefore, requires monitoring and periodic quality inspection so as to attain the objectives set by the supervisory board. It is against this background that the researchers intend to investigate the process of tertiary educational training in relation to the quality of the outputs (graduands) produced by such process through the use of statistical process control techniques.

1.1 Aim and Objectives of the Study

The aim of this research is to apply a modified statistical process control techniques on the academic grades of students and to investigate the level of quality of ND and HND graduates produced by the Waziri Umaru Federal Polytechnic Birnin-kebbi and the extent to which the process conforms to the standard set by the NBTE. To achieve this aim, the following specific objectives were set:

- i. To apply statistical process control and modified quality control charts to detect the presence or absence of 'out of control' conditions in the academic grades obtained by the ND and HND graduands of the institution.
- ii. To determine whether or not the 'out of control' conditions exist on the 3rd and 4th semesters' grade performance of the selected students using the modified X- bar and R charts.
- iii. To determine whether or not the 'out of control' conditions exist on the CGPAs of the selected students in relation to department using the modified X- bar and R charts.
- iv. To determine whether or not the 'out of control' conditions exist on the CGPAs of students in relation to the selected programme of study using the modified X- bar and R charts.

2.0 MATERIALS AND METHODS

Higher education institutions are required to evaluate program quality through cyclical program review processes (Alana, Catharine, and Shannon , 2022). The institution selected for this study (the Waziri Umaru federal Polytechnic Birnin Kebbi) was clustered into four distinct schools. The four schools are: School of Science and technology,

School of Engineering, School of Environmental studies and School of Business Administration and Management. Under each school, two departments were selected. Equally, under each department, two programmes (ND and HND) were considered. And finally, in each programme, student's CGPAs at both previous and graduation semesters were taking for the study.

Doreen (2021) affirmed that choosing a sampling technique depends greatly on the goal, and type of the research. The population under study is estimated at 11,500 student's academic records. The academic records in previous and graduating semesters of students at both ND and HND for seven sessions were considered. The seven sessions include: 2014/2015, 2015/2016, 2016/2017, 2017/2018, 2018/2019, 2019/2020 and 2020/2021. A sample of seven hundred and twenty (720) records was examined. A total of 20 students each were selected from a programme per department per session. The departments selected are: Public Administration, Business Administration, Accountancy, Electrical engineering, Mechanical engineering, Estate Management and Valuation, Building Technology, Accountancy, Computer Science, and Statistics.

The cumulative grade point averages (CGPAs) of twenty (20) students in each of the two programmes (ND and HND) for seven (7) sessions were taken. The CGPAs in both third (3rd) and final (4th) called the standard error of the mean and can be further expressed as,

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \quad (3)$$

Again, the overall sample mean, \bar{x} , is an unbiased estimator of μ . Hence substituting equation 3 and \bar{x} in equations 1 and 2, respectively, yields,

$$UCL = \bar{x} + 3 \frac{\sigma}{\sqrt{n}} \quad (4)$$

$$LCL = \bar{x} - 3 \frac{\sigma}{\sqrt{n}} \quad (5)$$

Zacharia (2018) uses the X bar chart as shown in equations 4 and 5. Control charts are graphical representations based on normal distribution (Sengoz, 2018). The charts are classified into two: attributes and variable control charts. Control charts methodologies are generally applied as useful tools in the assessment of different characteristics of various processes and products

semesters were considered. While the CGPAs in the third semester were considered to be the "work-in-progress" of a student, the final semester CGPAs were recorded as the "final-grade" of the student.

However, in this research, the researcher thought a modified version of equations 4 and 4 can be formulated and used. This is achieved by introducing a Correction Factor (CF). The sample values in each record in the data is observed to be small (only two values per record: third and final semester CGPAs) and hence the factors for control chart value associated with X bar and R charts, respectively, are likely to increase. When the factors for control chart increases therefore, the 3 sigma standard deviation will in turn increase. Again, an increase in the 3 sigma standard deviation will result to an increase in the two control limits. However, to control this possible increase in the two extreme control limits of the chart, the correction factor can be introduced. The

correction factor (CF) introduced is thus: $\sqrt{\frac{N-n}{N-1}}$

Where N = total population, n = size of sample
Recall that the Shewhart control chart for mean is given in equations 1 and 2, respectively (Montgomery, 2009).

$$UCL = \mu + 3\sigma_{\bar{x}} \quad (1)$$

$$LCL = \mu - 3\sigma_{\bar{x}} \quad (2)$$

Where

$\sigma_{\bar{x}}$ is the standard deviation of \bar{x} , otherwise

(Dike et al, 2018). It can be shown that an estimator of the process standard deviation σ is the average range divided by d_2 , a constant that depends on the sample size n. That is,

$$\text{Estimator of } \sigma = \frac{\bar{R}}{d_2} \quad (6)$$

Substituting $\frac{\bar{R}}{d_2}$ for σ in equations 3.4 and 3.5 gives,

$$UCL = \bar{x} + 3 \frac{\bar{R}/d_2}{\sqrt{n}} \quad (7)$$

$$LCL = \bar{x} - 3 \frac{\bar{R}/d_2}{\sqrt{n}} \quad (8)$$

Using the relation,

$$A_2 = 3/(d_2\sqrt{n}) \quad (9)$$

Hence the three variables, often substitution, can be obtained using equations:

$$CL = \bar{x} \quad (10)$$

$$UCL/LCL = \bar{\bar{x}} \pm A_2 \bar{R} \quad (11)$$

Substituting the CF into equation 11 yields a modified X bar chart as follows:

$$LCL = \bar{\bar{x}} - A_2 \bar{R} \sqrt{\frac{N-n}{N-1}} \quad (12)$$

$$UCL = \bar{\bar{x}} + A_2 \bar{R} \sqrt{\frac{N-n}{N-1}} \quad (13)$$

The range chart, or R chart for short, can be used to control the variability of a process. The UCL and LCL for R chart are,

$$UCL/LCL = \bar{R} \pm 3\hat{\sigma}_R \quad (14)$$

Anderson, Sweeney and Williams (2004) also showed that an estimate of the standard deviation of the range, denoted by $\hat{\sigma}_R$, is

$$\hat{\sigma}_R = d_3 \frac{\bar{R}}{d_2} \quad (15)$$

By substituting equation 15 in 14, this yields,

$$UCL/LCL = \bar{R} \pm 3d_3 \frac{\bar{R}}{d_2} \quad (16)$$

Thus the UCL and LCL are further given by,

$$UCL = \bar{R} \left(1 + 3 \frac{d_3}{d_2}\right) \quad (17)$$

$$LCL = \bar{R} \left(1 - 3 \frac{d_3}{d_2}\right) \quad (18)$$

Letting,

$$D_4 = \left(1 + 3 \frac{d_3}{d_2}\right) \quad (19)$$

And,

$$D_3 = \left(1 - 3 \frac{d_3}{d_2}\right) \quad (20)$$

The UCL and LCL can be re-written as,

$$UCL = \bar{R} D_4 \quad (21)$$

$$LCL = \bar{R} D_3 \quad (22)$$

The modified R bar chart is obtained using similar procedure as discussed above. Substituting the correction factor into equations 21 and 22, respectively, yields the following modified UCL and LCL for R bar charts:

$$UCL = D_4 \bar{R} \sqrt{\frac{N-n}{N-1}} \quad (23)$$

$$LCL = D_3 \bar{R} \sqrt{\frac{N-n}{N-1}} \quad (24)$$

The American Society for Testing and Materials Manual on Presentation of Data and Control Chart Analysis provides values for A_2 , D_4 and D_3 .

3.0 DISCUSSION OF THE RESULTS

The UCL, CL and LCL for the X bar chart were obtained as 3.03, 2.70 and 2.37, respectively. This shows that the overall CL of the entire performance of the students under study was 2.70. This indicates that the average performance was just slightly lower than the expected CGPA of 2.75, as prescribed by the supervisory board, the NBTE. Interestingly also, the X bar Chart of the distribution, as presented in figure 1, showed that the entire process was under control. This was because, not only that, all the data points were within the control limits, but also that the distribution of the points within the chart were closely spread around the CL. The result therefore is in agreement with the average standard set by the NBTE. This was evident by the fact that, of all the twenty sample member averages, none was below the CGPA of 2.50 and equally none was up to a CGPA of 3.00.

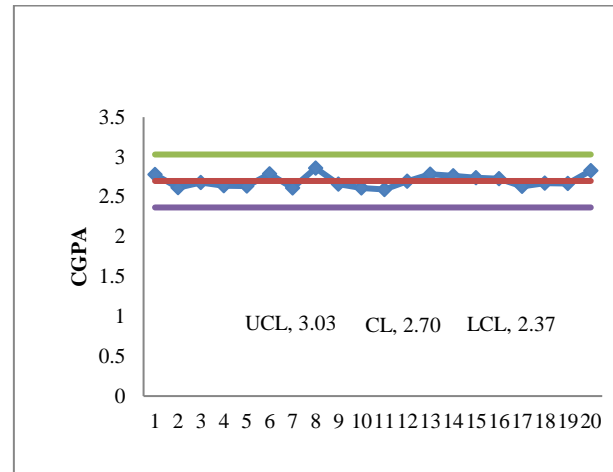


Fig.1: X - bar Chart for National Diploma (ND) All Departments

The R chart of the distribution was equally constructed. Figure 2 showed that only one point, at the 19th observation, was outside the UCL. The chart also indicates that the process was “educationally” under control as there was not a single point below the LCL or evidence of an outlier on the chart.

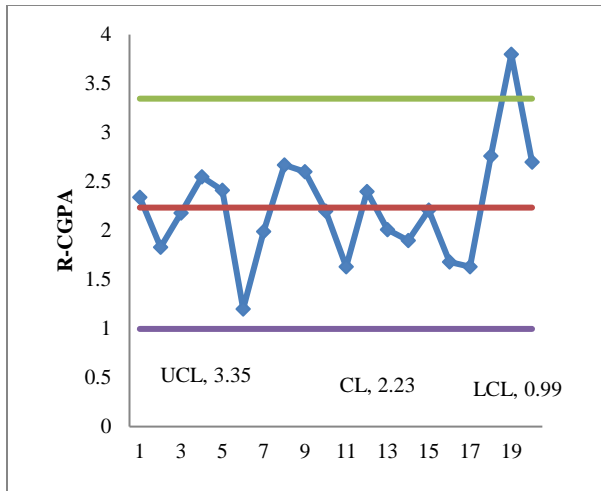


Fig.2: R – bar Chart for National Diploma (ND) All Departments

Like in the ND programmes, the CGPs of all HND students across all departments were considered and analysed using the grouped modified X bar and R charts. The UCL, CL and LCL of the X bar chart were 2.94, 2.74 and 2.53, respectively. This can be seen as presented in table 4.03. Interestingly also, the CL was almost exactly the same as the population mean of 2.75. Again also, the X bar chart as shown in figure 3 has revealed even a more interesting situation indicating that the process was absolutely under control. This was evident by the fact that all the data points were within the control limits and homogeneously spread along the CL.

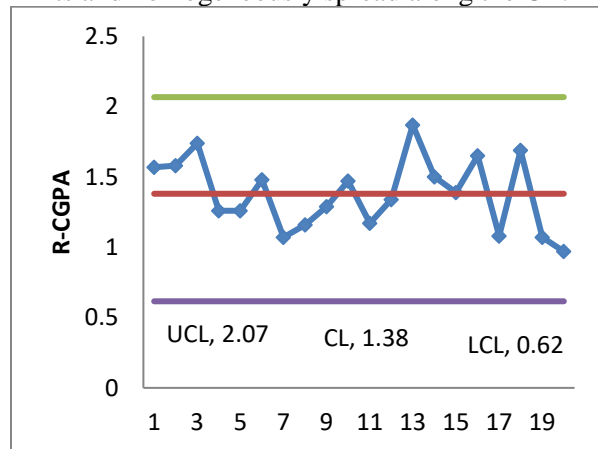


Fig. 3: R - bar Chart for Higher National Diploma (HND) All Departments

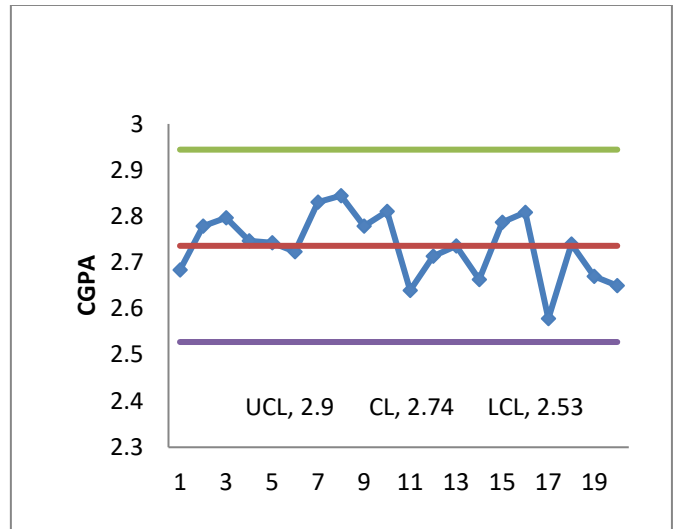


Fig.4: X - bar Chart for Higher National Diploma (HND) All Departments

Moreover, like in the ND programme, the CGPA of the HND students was revolving around the Lower Credit certificate limit. Although, however, there was an observed improvement in the strength of the CGPAs of HND students over that of the ND students, the overall average CGPAs of the two Diplomas agrees with the specification by the NBTE.

The R chart as shown in figure 4, has indicated a stable and under control process with all the data points within the UCL and LCL of the chart. Although, the control limits values appeared to be smaller than that of the ND, however, there was evidence of steady improvement in performance by the students within the two semesters.

4.0 CONCLUSION

In academic process, quality of every graduand is measured by the performance and CGPA obtained by the candidate at the end of each programme. These CGPAs are used to determine the class of diploma to be awarded to each student at the completion of his programme. This study investigate the performance of Waziri Umaru Federal Polytechnic Birnin Kebbi Nigeria with the view to ascertain the level of quality of its graduands overtime and also to investigate the level of compliance to the standard quality of its products as provided by the National Board for Technical Education. Both the ND and HND programmes of the Institution were studied.

A statistical quality control process using a modified X bar and R charts was used to analysed the data. The use of modified X bar and R charts in this study has helped in reducing the variability in the data and further enhanced the ability of the charts to detect possible out of control academic process. The overall performance of the two programmes showed that the graduands of the Waziri Umaru Federal polytechnic Birnin Kebbi Nigeria have performed within a very comfortable limits set by the NBTE. Particularly, the HND performance had shown that there was improvement in performance from the ND programme.

5.0 RECOMMENDATIONS

Based on the results obtained and interpretations done above, the following recommendations are made:

- a. The Waziri Umaru Federal Polytechnic Birnin Kebbi, even though recorded a good average performance in both the ND and HND programmes, should put more effort in increasing the quality of its graduands. This can be achieved by employing more qualified lecturers, close supervision of young lecturers by senior ones, identifying and rewarding hard working staff, etc.
- b. The National Board for Technical Education should ensure that importance is attached to Merit in the award of certificate in all the institutions under its supervision. This can be done by lifting the policy/requirement of 75% success rate as a condition for re-accreditation of programme in our institutions. This will also reduce the arbitrary of award of marks by lecturers so as to ensure compliance to the requirement.
- c. The Government of Nigeria through the Federal Ministry of Education should attach more importance to Vocational and Technical Education in the Education sector. Technical Education is the key driver of every economy and meaningful development. Unfortunately, the researcher observed that the general average performance experienced in both programmes can be attributed to the criteria for admission. It has been observed that most students admitted into polytechnics are mere leftovers from the Universities admissions. In fact, even the Joint Admissions and

Matriculation Board (JAMB) cut-off marks for Polytechnics over the years have been much lower than the Universities. Hence, this means that even from the admission level, the candidate were just mere average candidates.

- d. The Government of Nigeria should also enact a policy for creating a more enable environment for technical education to thrive in the country. This can be achieved by providing special packages as incentives through scholarships and grants to both graduands and lecturers in the Polytechnics. This way, the technical education will be more competitive and will address the problem as outlined in recommendation (iii) above.
- e. This research can be further developed by co-researchers to cover more Polytechnics in order to have a more general view on the level of quality of our graduands in the Technical Institutions in Nigeria.

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