USE OF SHEWART CONTROL CHART TECHNIQUE IN MONITORING STUDENT PERFORMANCE

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Abstract. Students' academic performance was assessed using quality control techniques. Results show that performance of students was out of control using mean chart ($\bar{X}$-Chart) with Central Limit (CL) = 2.35, Upper Control Limit (UCL) = 3.20 (although grade points above this limit may not necessarily be regarded as out-of-control-points for academic performance) and Lower Control Limit (LCL) = 1.51. Similarly, students' performance was also found not to be in control using Standard Deviation (S-Chart) with Central Limit (CL) = 0.71, Upper Control Limit = 1.34, Lower Control Limit = 0.001 approximately.The chart shows point falling below lower control limit (1.51); that is, students with poor performance. This can be adopted as a bench mark for assessing whether or not students should proceed to the next academic level, some sort of "Academic Good-Standing". Above the upper control limit are exceptional/ good results. The average performance of students is 2.35

which corresponds to third class grade; this implies that on average, students graduate with third class.

Keywords: quality, performance, cumulative grade point average (CGPA)

Introduction

There is a clamor for graduates who can match up to the demands of the Nigerian market (or anywhere else in the world), graduates who can deliver according to the demands of their employers and the specifics of their work place, but this would probably never be met if the process that churns out these graduates is not properly monitored. One way of truly assessing the quality of graduates being churned out is by assessing their academic performance in their respective varsities. Hence, to ensure quality graduates the quality of their performances in academics need to be closely monitored. There is need to establish a scientific approach to monitoring students' academic performance to ensure they conform to specification.

This paper seeks to establish the use of quality control tools in monitoring the quality of students' academic results so as to ensure that qualified graduates being turned into the labor market and also to construct a confidence lower bound below which grade points can be regarded as not conforming to standards.

Performance, an outcome of education, is the extent to which a student, teacher or institution has achieved his education goals. Academic achievement is commonly measured by examination or continuous assessment but there is no general agreement on how it is best tested or which aspects are most important.

Education, in general sense, is the means through which the aims and character of a group of people living from one generation to the next is achieved. Generally, it occurs through experience that has a formative effect on the thoughts feelings or acts. In its narrow, technical sense, education is the formal process by which society deliberately transmits its accumulated knowledge, skills, customs and values from one generation to another, for example, instructions in school". Examination, in an academic or professional context, are test which aims at determining the ability of student or prospective practitioners. Examination are usually written test although some may be practical and vary greatly in structure, contents and difficulty depending on the subject, the age group or level of the tested persons and profession .

A comprehensive examination is a specific type of examination by graduate students, which may determine their ability to continue their studies. A final examination is test given to students at the end of a course of study or training. Although the term can be used in the context of physical training, it most often occurs in the academic world. Most high schools, colleges and universities run final exams at the end of a particular academic term, typically a quarter or semester ,or more traditional at the end of a complete degree course.

Grades are standardized measurement within a subject area and can be assigned in letters (A,B,C,E,F),as a range (for example 1.0-5.0), as a number out of a possible total (for example, out of 20 or 100), as description (excellent ,good, satisfactory , need improvement.), in percentage, or as common in some post-secondary institution in some countries, as a grade point average (GPA).

GPA is calculated by taking the number of grade point a student earned in a given period of time divided by the number of credits taken. The GPA can be used by potential employers or post-secondary institution to assess and/or compare applicants. A cumulative grade point average, CGPA, refers to a student's grades for all semesters and courses completed up to a given academic session, whereas the GPA may only refer to one semester.

Students' academic performance is assessed by use of tests, assignments and examinations. Much as it is normal for students in an educational institution to perform well and others poorly.

In every educational institution academic performance need to be controlled quantitatively. The method and procedures to evaluate the student performance always demand tremendous efforts ranging from student's assessment to result processing, which is the best method to control student performance.

Our aim in this work is focused on finding out whether the performance of students is significantly distributed according to academic patterns using the quality control procedure; detecting any statistically significant positive or negative shift in a student's GPA as from a desired target level using quality control charts.

This study will facilitate proper monitoring of student performance in the university so that "non-conforming" scores can be identified easily so that such students could be properly and adequately advised so as to forestall poor outcome in the near future**.**

Statistical process control

Variation can either be due to random (chance) causes and/or assignable causes. Some stable system of chances is inherent in any particular scheme of production and inspection (Kotz & Johnson, 1988). But for products to maintain their standards, the assignable causes due to personnel, machines or material must be eliminated or at least reduced. Any process that is operating in the presence of assignable causes can be said to be out of control (Montgomery, 1991).

Gupta & Gupta (2006) defined statistical quality control as one of the most useful and economically important applications of the theory of sampling in the industrial field.

Keller (1999) defined quality control as Statistical Process Control which refers to one of a variety of statistical techniques used to develop and maintain a firm ability to produce high quality goods and services. Aczel (1999) also stated that the capability of any process is the natural behavior of the particular process after disturbances are eliminated

Statistical process control (SPC) is an important tool used widely in manufacturing field to monitor the overall operation. SPC can be applied to all kind of manufacturing operations. The significant application of the SPC analysis to the operation will make the process more reliable and stable (Grant & Leavenworth, 1979).

Statistical process control (SPC) involves using statistical techniques to measure and analyze the variation in processes. Most often used for manufacturing processes, the intent of SPC is to monitor product quality and maintain processes to fixed targets. Statistical quality control refers to using statistical techniques for measuring and improving the *quality* of processes and includes SPC in addition to other techniques, such as sampling plans, experimental design, variation reduction, process capability analysis, and process improvement plans. The consistent, aggressive and committed use of SPC to bring all processes under control, recognize and eliminate special causes of variation, and identify the capability of all operations is a key requirement. SPC is defined as prevention of defects by applying statistical methods to control the process (Montgomery, 2005).

Methodology

Control chart for variables are used to monitor the mean and the variability of process distribution.

$\bar{X}$-Chart

An $\bar{X}$-chart (read “X-bar Chart) is used to see if the process is generating output on average consistent with a target value management has set for the process. A target value is used when a process is completely redesigned and fast performance is no longer relevant. The control limits for the $\bar{X}$-Charts are

$$UCL_x = \bar{\bar{X}} + A_2\bar{R} \text{ and } LCL_x = \bar{\bar{X}} - A_2\bar{R}$$

where $\bar{\bar{X}}$= control line of the chart, which can be either the average of past sample means or a target value set for the process A_2 constant to provide three- sigma limit for the sample mean (Stevenson, 2010).

This section presents the steps required for the construction of statistical quality control limits for the students' scores over time. When this tool is used to monitor students' performance (GPAs), the out of control signal would occur when the data falls below the lower control limit. Exceeding the control limit indicates that there is an improvement in performance. The process design uses Shewart types of control chart based on the $\bar{X}$ *and* S charts (Bakir & McNeal, 2010).

Source of data

Data were collected from records of students' CGPA in the Department of Statistics and Operations Research, Modibbo Adama University of Technology, Yola, from 2009/2010, 2010/2011, 2011/2012, 2012/2013 and 2013/2014 academic sessions. Thus, data for this work is a secondary data of sixty-six observations on student G.P. over a period of five academic sessions.

List of symbols

$\bar{\bar{X}}$ − Average of the subgroup average

$\bar{X}$ − Average of subgroup

n − Number of subgroups

UCL − Upper Control Limit

LCL − Lower Control Limit

σ − Population standard deviation of the subgroup averages

$\bar{R}$ −Average of the range

R − Individual range value for the sample

A_2 −Approximation factor used to calculate control limits

σ_R − Population standard deviation of the subgroup ranges

D_3 − Approximation factor used to calculate range chart control limits

D_4 − Approximation factor used to calculate range chart control limits

d_2 − Approximation factor for calculating within subgroup standard deviation

$\bar{\bar{X}}$ – chart (variable control chart

The $\bar{X}$– Chart monitors the process mean or levels (we wish to run near a desired target levels).When the sample size n is small e.g., (< 30) bu

$$X\sim N(\mu,\sigma^2), \text{then } \bar{X}\sim\left(\mu,\frac{\sigma^2}{n}\right)$$

$$E(x)=\mu \text{ and } var(x)=\frac{\sigma^2}{n}$$

$$\text{UCL} = \bar{\bar{X}} + 3\sigma\,\bar{\bar{X}} \quad \text{upper control limit}$$

$$\text{CL} = \bar{\bar{X}} \text{ control limit}$$

$$\text{LCL} = \bar{\bar{X}} - 3\sigma\,\bar{\bar{X}} \text{ lower control limit}$$

where

$$\sigma_x = \frac{\sigma}{\sqrt{n}}, \text{ an estimate of } \sigma \text{ is } \frac{\bar{R}}{d_2} \text{ and } d_2 \text{ is a constant Hence,}$$

$$\text{UCL } \bar{X} = \bar{\bar{X}} + \frac{3R}{d_{2\sqrt{n}}}\text{; CL } \bar{X} = \bar{\bar{X}} \text{ LCL; } \bar{X} = \bar{\bar{X}} - \frac{3R}{d_{2\sqrt{n}}}$$

Putting $\frac{3}{d_{2\sqrt{n}}} = A_2$ we have that:

$$\text{UCL } \bar{X} = \bar{\bar{X}} + A_2\,\bar{R}\text{; CL } \bar{X} = \bar{\bar{X}}$$

$$\text{LCL } \bar{X} = \bar{\bar{X}} - A_2\,\bar{R}$$

The value of A_2 is contained in table and depends on the value of n where $\bar{\bar{X}}$ = the mean of all subgroup means.

S-chart (variable control chart)

If X is normally distributed, then the standard deviation is $s - \sigma\sqrt{1 - C_4^2}$, so that $\frac{\bar{S}}{C_4}$ is an unbiased estimate of σ hence, for a normal case the standard deviation of X should be in the form

$$\frac{S}{C_4}\sqrt{1 - C_4^2}$$

and, therefore, the limit of S-chart is given by:

$$UCL = \bar{S} + 3\frac{\bar{S}}{C_4}\sqrt{1 - C_4^2}$$

and

$$LCL = \bar{S} - 3\frac{\bar{S}}{C_4}\sqrt{1 - C_4^2}$$

$$UCL = \bar{S}\left(1 + \frac{3}{C_4\sqrt{1 - C_4^2}}\right)$$

and

$$LCL = \bar{S}\left(1 - \frac{3}{C_4\sqrt{1 - C_4^2}}\right)$$

Putting

$$B_4 = 1 + \frac{3}{C_4}\sqrt{1 - C_4^2}$$

and

$$B_3 = 1 + \frac{3}{C_4}\sqrt{1 - C_4^2}$$

we have

$$UCL = B_4\bar{S}$$

Upper control limit

$CL = \bar{S}$ control limit

$LCL = B_3\bar{S}$ lower control limit

The limits for the corresponding $\bar{X}$- chart is:

$$UCL = \bar{S} + 3\frac{\bar{S}}{C_4}\sqrt{n} \text{ And } LCL = \bar{S} - 3\frac{\bar{S}}{C_4}\sqrt{n}$$

$$\text{If } A_3 = \frac{3}{C_4}\sqrt{n}$$

then

$UCL = \bar{X} + A_3\bar{s}$ upper control limit

CL = $\bar{X}$ control limit

$LCL = \bar{X} - A_3\bar{s}$ lower control limit.

Application of $\bar{X}$ and $\bar{S}$ chart (mean and standard deviation using 3 σ

Results were obtained using the SPSS package.

Interpretation of the control chart for mean chart (Fig. 1)

$$UCL_x = \bar{\bar{X}} + A_3\bar{S} = 3.20;\ LCL_x = \bar{\bar{X}} - A_3\bar{S} = 1.51;\ CL = \bar{\bar{X}} = 2.3$$

From the analysis of the mean chart of the student GPA of 2009/2010, not all the points are within the control limits. From the chart, we can observe that the observation points corresponding to the 2^{nd},5^{th},10^{th},22^{nd},27^{th},28^{th},29^{th},37^{th},39^{th},44^{th}, 50^{th},52^{nd}, 56^{th},60^{th} and 66^{th} lie outside the control limits. Hence the student performance is out of control this implies that some assignable courses of variations are operating in the student performance, which should be detected and corrected. This work focuses on point falling below control limit that is student with a poor performance. Since above, the upper control limit is an exceptionally good result. The average performance of students is 2.35 which correspond to third class grade; this implies that the average students are graduates with third class.

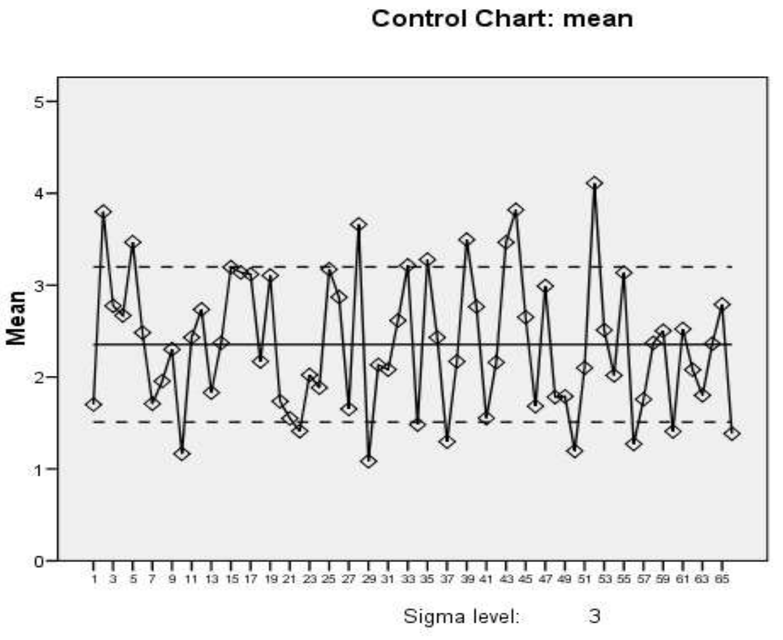

Fig. 1. Control Chart for Mean

The upper control is limit is 3.20. That is, there are students with good performances, some of which are second class upper while some are second class lower. The lower control limit is1.51. Students below this are those with poor performance. This lower control limit can be adopted as lower bound for academic performance below which they can be regarded as out of control. This is benchmark grade for “Academic Good Standing”.

Interpretation of the control chart for standard deviation S (Fig. 2)

$CL = \bar{S} = 0.714 \qquad UCL = B_4\bar{S} = 1.344 \qquad LCL = B_3\bar{S} = 0.00$

From the control chart, not all the point are within the control limits, the sample point corresponding to 4^{th} and 9^{th} lies outside the control chart limits. Hence, the students’ performance is not in control. There is an assignable cause of variation that is operating in the student performance. The points that fall below the lower control limits are students with poor performance and above the upper control are exceptional result.

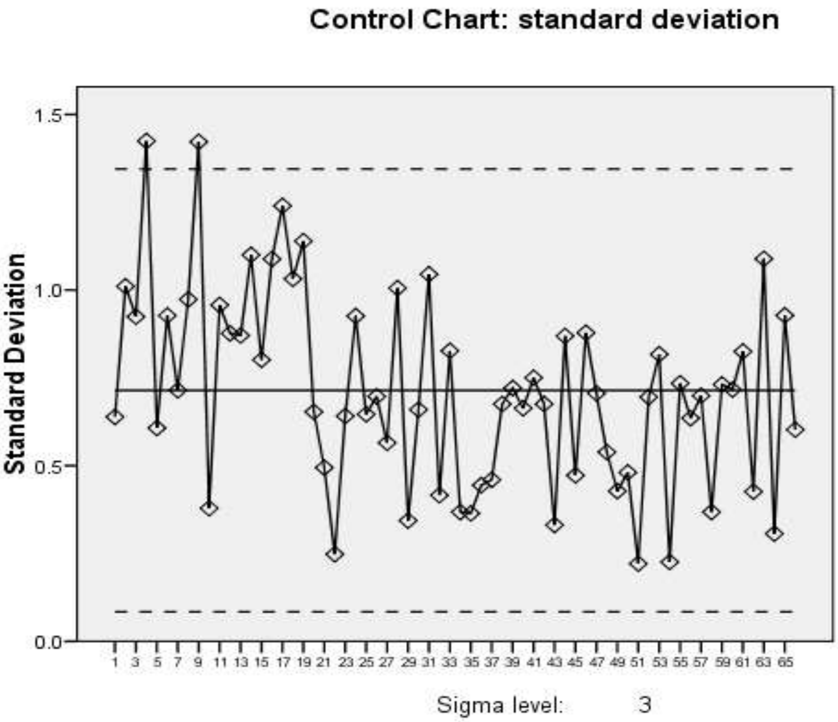

Fig. 2. Control chart for standard deviation

Summary

Statistical quality control is able to differentiate between chance cause factor which are fundamental to all process and assignable cause's factor which can be isolated and be removed from the student performance process. By using the range of acceptability, it is possible to determine when student performance is stable operating without an assignable causes that is to say, to know whether the student performance is statistically control or not.

The study is best summarized with regard to application and assessment made from statistical quality control, using the student CGPA. The assessment is as follows; from mean chart ($\bar{X}$-chart), application to determine whether student performance is statistically in control or not, it was found to be out of control with the central limit $\text{C L} = 2.35, \text{UCL} = 3.20$ and $\text{L C L} = 1.51$.

The Lower Control Limit can be used as an "Academic Good-standing" criteria for assessing students' performance from the s- chart, application to determine whether student performance is in control or not , was found to be not statistically in control with the central limits $\text{CL} = 0.71$, $\text{UCL} = 1.34$ and $\text{LCL} = 0.00$. In applying the s- chart to find the central tendency, the student performance was found to be not statistically control. By looking at the control chart tables all the samples points are not within the range.

Conclusion

First, the causes underlying the charting statistics that are less than the lower control limits were identified which indicate a negative shift in students CGPA. Secondly identify the reason for charting statistics falling above the upper control limit, which indicate the positive shift in student CGPA. Then, device solution to correct poor student performance and implement factors that result in improved student performance. If the charting statistics for all the semester fall within the control limits, the student has maintained the desire target GPA value.

Recommendation

A control chart is the graphic monitor of student performance. With the recognition that G.P is an important aspect of performance, department should initiate and propagate whole range of program to improve student performance.

Also, the department can adopt a minimum Academic benchmark of 1.50 in each level to adjudge whether or not to pass a student.

It worthy to note that the average performances of the student is 2.35 which correspond to third class grade; this implies, that on the average, student graduate with third class.

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