UTILIZING STUDENT PERFORMANCE DATA IN MONITORING NEW CURRICULUM IN CONSTRUCTION TECHNOLOGY USING STATISTICAL PROCESS CONTROL (SPC)

Haroun M. Masnar[1] and Consorcio S. Namoco Jr.[2]

[1]Division of Engineering Technology, Mindanao State University-Main Campus, Marawi City, Philippines

[2]College of Technology, University of Science and Technology of Southern Philippines, Cagayan de Oro City, PhilippinesEmail: haroun.masnar@msumain.edu.ph

ABSTRACT: *The study aims to assess the performance of students who have enrolled in a recently updated construction technology curriculum. This involves the use of Statistical Process Control (SPC) in which the study intends to demonstrate its use as an alternative approach for monitoring and evaluating the effectiveness of the newly revised curriculum in construction technology. The authors utilize P charts constructed using MS Excel to analyze the data collected. The data consists of performance patterns and trends within the curriculum, obtained by breaking down the data into semesters and plotting cumulative data of courses. The study emphasizes the importance of ongoing monitoring and evaluation of the curriculum implementation. It should be noted that the sample size of the data is unequal due to various reasons, such as the irregular offering of courses due to student petitions and the impact of the COVID-19 pandemic. The analysis focuses on the 13 major courses offered in the program, excluding mandated courses and general education. The findings provide insights into identifying areas for improvement in curriculum implementation.*

Keywords: Statistical Process Control, Construction Technology Education, Curriculum Monitoring, Student Performance Evaluation, Higher Education

1. INTRODUCTION

In response to the call of the Commission on Higher Education (CHED) in the Philippines on the adoption and implementation of quality assurance in higher education institutions (HEIs) in the country through CMO No. 46, Series of2012 which leads to a revision in curriculum among educational programs thru series of issuances of policy guidelines and minimum requirements in general education. Instead of dissolving, the Division of Engineering Technology (DET) of Mindanao State University (MSU) revised and updated its curriculum to a two-year diploma in construction technology that is intended to continuously meet the demand of manpower requirements in the region's construction sector. The creation of a curriculum is just the beginning. At this juncture, the graduates' comprehension of how to fulfill employer requirements is rudimentary and hazy. In reality, any framework for developing curricula would demonstrate a cyclical process for continual improvement, with monitoring playing a key role. The process for evaluating curricula and programs is not uniform [1]. Hence, this study explores the use of Statistical Process Control (SPC) as an alternative strategy that has been effectively utilized for decades in improving the quality of the manufacturing industry. Quality isn’t exclusive to manufacturing goods, it’s also significant in other domains like the education sector [2]. The introduction of the Statistical Control Chart concept in 1924 by Walter A. Shewart marks the birth of Statistical Quality Control (SQC) primarily intended to control the quality of manufactured goods [3]. This concept was successfully used in various sectors of industry from manufacturing and subsequently to the service sector [4]. Recent applications of SPC techniques in the industry settings include identifying causes of defects in PVC pipe production [5], cost and project monitoring in a construction project [6], improvement of quality of weights of bags in feed production [7], and many others. Some of the recent applications of SQC techniques in academic settings include the evaluation of self-learning modules for basic education [8], the assessment of the performance of graduates in the licensure examination for teachers [9], the evaluation of student performance [10], and many others. The SPC approach has the recognition to effectively monitor and diagnose processes [11]. It aids in evaluating the variability of educational processes by distinguishing between assignable causes and random causes, a prominent approach for tracking process performance, detecting deviations, and measuring progress in program improvement [12]. Student performance data on the other hand is a valuable input that needs to be recognized, it has a vital role in ensuring the effectiveness of education and training. As highlighted by [13], currently, only a fraction of this data is being analyzed.

This study aims to leverage the student performance data in identifying subject areas that need attention purposely as a means to monitor the implementation of the newly revised curriculum through the use of SPC. It seeks to enhance our comprehension of the utility of employing SPC in the monitoring of curriculum and program processes. By analyzing students' performance data, extends to improving the quality of teaching and fostering an optimal learning experience. Through this means, the study candetect courses that require immediate attention and intervention in instances of poor control which in turn, enables a proactive approach to monitoring a newly developed curriculum, and helps to ensure that students' educational goals are met.

2. MATERIALS AND METHODS

Considering the nature of the data collected shown in Table 1, a *P*-chart is most appropriate to use among the SPC tools to measure the proportion of defective among the sample size (officially enrolled students). *P*-charts are used to measure the proportion that is defective in a sample [14]. In categorizing the student performance, we classify them as conformance (Passing rate) and non-conformance (non-passing rate) which seems appropriate for this study [10]. Conforming students refer to the compliance to the course within its duration, while non-conforming are students who failed to achieve a passing rate during the course duration, suchnon-passing rates include 5.0 (failed), incomplete (INC), officially dropped (ODP), and unofficially dropped (DP). A three sigma limits are used as widely accepted in the education sector [15].

Table 1: Fraction Defect

Academic Year, Term	CourseCode	Sample Size(Total Officially Enrolled)	Non-Conforming	Fraction Defective
2018-2019, 1st	DCT111	23	5	0.2174
	DCT112	24	7	0.2917
	DRG100	23	3	0.1304
2018-2019, 2nd	DCT121	7	3	0.4286
	DCT123	13	2	0.1538
2019-2020, 1st	DCT111	108	14	0.1296
	DCT112	110	11	0.1000
	DCT113	109	14	0.1284
	DCT131	10	2	0.2000
	DCT133	8	2	0.2500
	DCT134	10	2	0.2000
	DRG100	109	51	0.4679
2019-2020, 2nd	DCT123	32	32	0.0000
2020-2021, 1st	DCT111	106	24	0.2264
	DCT112	78	17	0.2179
	DCT113	106	27	0.2547
	DCT131	20	5	0.2500
	DCT132	75	31	0.4133
	DCT133	67	29	0.4328
	DCT134	73	11	0.1507
	DRG100	141	36	0.2553
	DRG101	62	21	0.3387
2020-2021, 2nd	DCT121	30	22	0.7333
	DCT122	42	4	0.0952
	DCT123	91	26	0.2857
2021-2022, 1st	DCT111	158	18	0.1139
	DCT112	157	17	0.1083
	DCT113	158	21	0.1329
	DCT131	40	10	0.2500
	DCT132	40	6	0.1500
	DCT133	44	16	0.3636
	DCT134	10	2	0.2000
	DRG100	205	40	0.1951
2021-2022, 2nd	DCT121	60	8	0.1333
	DCT122	60	5	0.0833
	DCT123	37	3	0.0811
	DCT197	35	1	0.0286
2022-2023, 1st	DCT111	38	3	0.0789
	DCT112	39	3	0.0769
	DCT113	21	1	0.0476
	DCT131	113	4	0.0354
	DCT132	102	7	0.0686
	DCT133	113	11	0.0973
	DCT134	49	1	0.0204
	DRG100	41	4	0.0976
2022-2023, 2nd	DCT121	23	1	0.0435
	DCT123	17	3	0.1765

The study utilizes MS Excel to construct *P*-charts. Below is to elaborate on its calculations:

Subgroups of *n* units over time were observed. We inspect (test) the *n* units in each subgroup and determine the number *d* of these units that are nonconforming.

We then calculate for each subgroup $P_i = \frac{d_i}{n_i}$ the fraction of nonconforming units in the subgroup.

Suppose *m* samples are given, each of size *n*.

Step 1. Calculate the fraction of nonconforming units to each subject P_1, P_2... P_k.

$$P_{i \ldots l} = \frac{Number\ of\ nonconforming\ students}{total\ Number\ of\ Officially\ enrolled}$$

Step 2. Calculate the centerline, $\bar{P} = \frac{1}{k}\sum_{i=1}^{k} P_i$

Step 3. Using the formulas below, we determine the control limit values:

$$\mathrm{UCL} = \bar{\mathrm{P}} + z\sigma_{\mathrm{P}}$$
$$\mathrm{UCL} = \bar{\mathrm{P}} - z\sigma_{\mathrm{P}}$$

Where:

z $= standard\ normal\ variable\ (3\ sigma\ level)$
$\bar{P}$ $= the\ sample\ proportion\ defective$
$\sigma_P = the\ standard\ deviation\ of\ the\ average\ proportion\ defective$

The standard deviation of the sample is computed as follows:

$\sigma_P = \sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$, where *n* is the sample size.

Step 4. On the graph sheet, the sample numbers are to be plotted on the x-axis and P_i's on the y-axis.

Step 5. The *P*-chart is constructed such as:

a. Plot the lines of $\bar{P}$, UCL, and LCL
b. Plot the points whose coordinates are (1, P_1), (2, P_2)… (k, P_k).
c. Connect the adjacent points by line segments.

It is presumed that the process is in control and that no more intervention is required as long as the points are plotted within its control bounds. However, any point plotted outside the range of control is seen as evidence of an out-of-control process, necessitating more inquiry to identify and address the assignable cause(s) behind this behavior [16].

3. RESULTS AND DISCUSSION

Data collected were based on the availability and per request of the researcher from the University registrar. Sample sizes are unequal due to various reasons. For example, courses may be offered untimely on its regular offering if there are petitioners as approved by the Office of the Vice Chancellor for Academic Affairs (OVPAA). The data used in this study are performance data of all students officially admitted in the new curriculum focused on the 13 major course offerings in the program. Mandated courses and general education are excluded from the analysis. It is also important to note that during 2nd term of the academic year 2019-2020 Covid19 global pandemic took place and all students are excused from non-conforming status instead, they are given a rate of P (pass) which is also eliminated in this analysis. The P- charts graph was generated using MS Excel, we plotted the performance data of every semester which resulted in Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5, and we summarized the cumulative fraction of defects of courses presented in Table 2, and plot the cumulative data of courses (Figure 6) to have a comprehensive view of analysis. Based on the data analysis presented, there are three courses that were identified to be out-of-control on some specific academic terms as listed in Table 3. However, on a cumulative basis presented in Figure 6, it shows that DRG100 and DRG101 are out-of-control which deviates outside their Upper Control Limits of 0.029 and 0.0092, respectively.

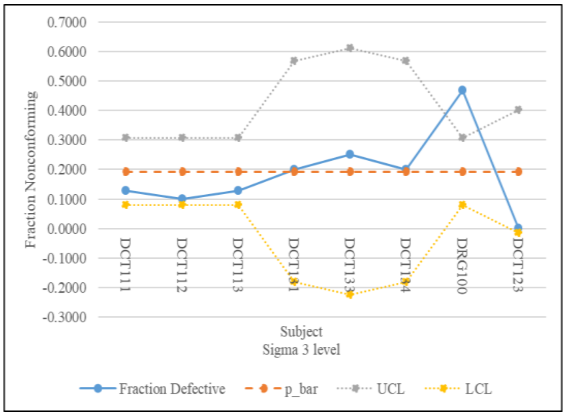

Figure 1. *P*-chart of Students' Performance Data for A.Y. 2018-2019

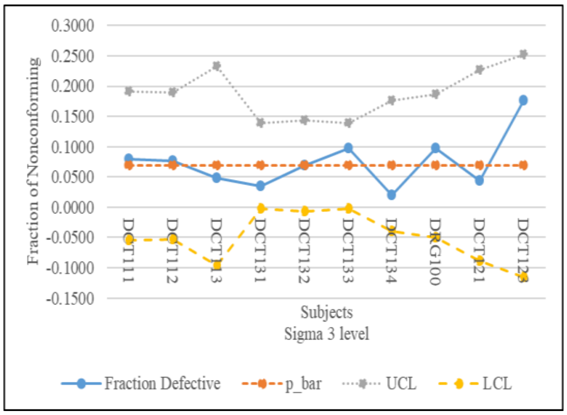

Figure 2. *P*-chart of Students Performance Data for A.Y. 2019-2020

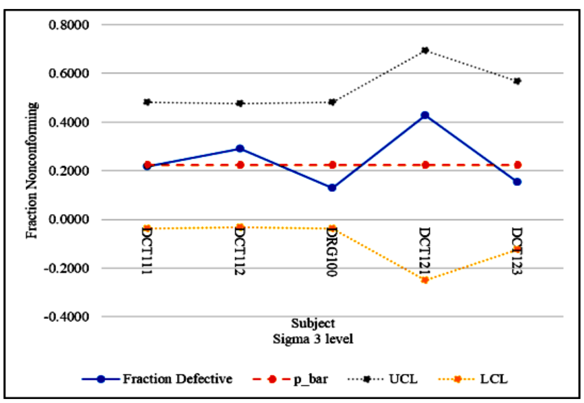

Figure 3. *P*-chart of Students Performance Data for A.Y. 2020- 2021

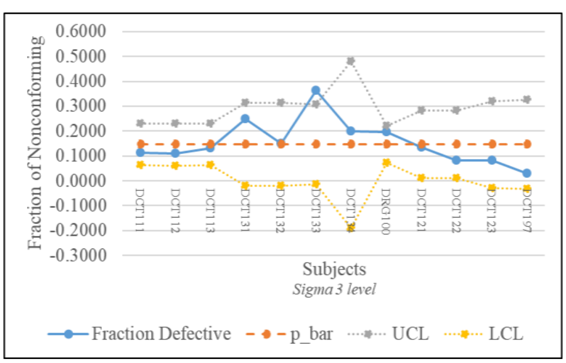

Figure 4. *P*-chart of Students Performance Data for A.Y. 2021-2022

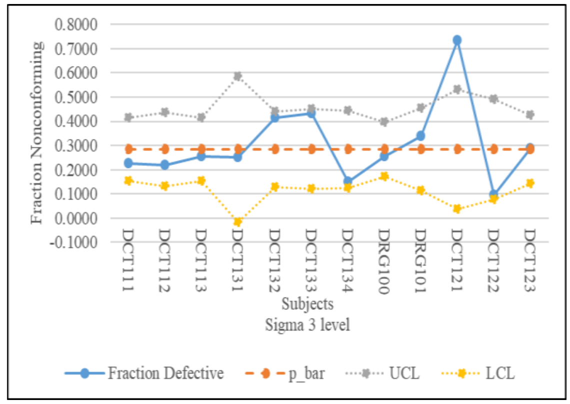

Figure 5. *P*-chart of Students Performance Data for A.Y. 2022-2023

Table 2: Cumulative Fraction Defect per Course

Course Code	Sample Size (Total Officially Enrolled)	Non-Conforming	Fraction Defective
DCT111	433	64	0.1478
DCT112	408	55	0.1348
DRG100	519	134	0.2582
DCT121	120	34	0.2833
DCT123	190	34	0.1789
DCT113	394	63	0.1599
DCT131	183	21	0.1148
DCT133	232	58	0.2500
DCT134	142	16	0.1127
DCT132	217	44	0.2028
DRG101	62	21	0.3387
DCT122	102	9	0.0882
DCT197	35	1	0.0286

Table 3: Out-of-Control Courses

Academic Year, Term	Course Code	Deviation from control Limits
2019-2020, 1st	DRG100	0.1608 outside the UCL
2020-2021, 2nd	DCT121	0.2024 outside the UCL
2021-2022, 1st	DCT133	0.0573 outside the UCL

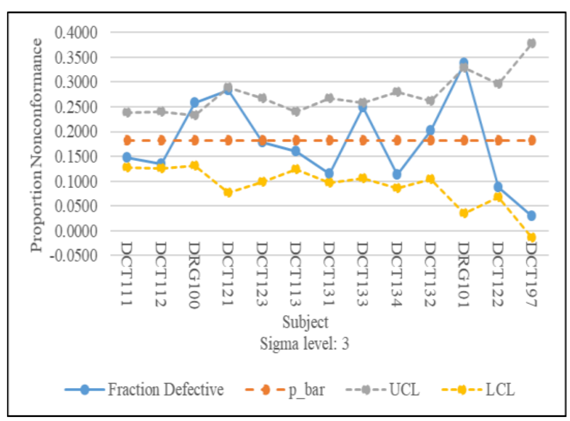

Figure 6. *P*-chart Based on Cumulative Data of Students' Performance

To achieve greater clarity on these results, three perspectives on the curriculum have to be distinguished Institutional perspective, Teachers' perspective, and Students' perspective [17]. Our primary data tells us that all subjects that are out-of-control were classified as laboratory-intensive courses. The priority goals, cultural values, policies, resource influence, and design implementation of the new curriculum in construction technology were disrupted due to the suspension of face-to-face classes in Higher education caused by the COVID-19 pandemic under Proclamation No. 922 by the office of the President. While online teaching possesses distinct advantages, it has a disparity in learning gains [18] [19] and has disrupted laboratory components to complement instructions [20]. The class size is another factor to consider as it was found to affect the performance rate of students [10]. The effectiveness of the new curriculum in construction technology is an assignable cause that can be controlled and mitigated to tune to its intended direction.

4. CONCLUSION

The construction of *P*-charts allowed for a comprehensive view of the data analysis. By breaking down the data into semesters and later on plotting the cumulative data of courses as shown in Figure 6, a detailed understanding of the performance patterns and trends within the curriculum was obtained. Ongoing monitoring and evaluation of the curriculum implementation are crucial. Addressing the identified areas of concern, such as courses with high non-conforming fractions and deviations from control limits, can contribute to the enhancement of the curriculum's effectiveness.

It is recommended that further research be conducted to examine the underlying factors that contribute to these variations and suggest specific measures for enhancing improvement. The utilization of SPC, specifically the *P*-chart, in assessing student performances among courses offered in a new curriculum provides a valuable alternative for promptly addressing and tracking their learning progress. By employing *P*-charts and data analysis techniques, we can readily identify unusual shifts and patterns that require attention in an ongoing curriculum being implemented. This approach carries substantial implications for curriculum design and the formulation of educational policies, as it strives to guarantee the delivery of high-quality education to students.

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