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STATISTICAL CONTROL ANALYSIS OF THE STUDENT'S FINAL ASSIGNMENT COMPLETION PERIOD AT THE MATHEMATICS AND NATURAL SCIENCES FACULTY ULM

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Abstract. *The final assignment is one of the requirements to get a bachelor's degree for college students at the Faculty of Mathematics and Natural Sciences (FMIPA) University of Lambung Mangkurat (ULM). The average period of completion of the final assignment in the year 2015 until 2019 is 8 months, while the determined specification by the guideline is 6 months. The aim of this research is to identify the quality cont09988okjkl;lkl;luyrol of the final assignment completion process and whether satisfy the determined specification using statistical quality control. The used data in this research is the student's final assignment completion period (variable data) and the nonconforming proportion of data (attribute data). The $\bar{x}$ and R control charts are used for variable data and p control chart for attribute data and process capability analysis. The result of variable data is that the average period of final assignment completion is statistically in control with a control limit of* 9,067 *months. For attribute data concluded that final assignment completion is statistically in control with a big average proportion that is* 86,11%. *For the capability analysis process by index C_p and C_{pk} value sequentially is* 0,447 *and for the DPU value is* 76,34%. *This shows that the completion period of the student's final assignment of FMIPA ULM is not capable to fulfill the specified standard of the period.*

Keywords: *control chart, final assignment guideline, process capability analysis, statistical quality control.*

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1. INTRODUCTION

The final assignment, also known as a mini-thesis, is based on Indonesia's National Constitution Number 20, the Year 2003, about the National Education System, which is applied to improve the quality of education in Indonesia. The Faculty of Mathematics and Natural Sciences (FMIPA) at the University of Lambung Mangkurat (ULM), one of the educational institutions in Indonesia, has adjusted the final assignment as a requirement to get a bachelor's degree.

Based on the Final Assignment Guideline book, which was published by FMIPA ULM, the standard of final assignment completion is one semester or six months. But, based on the data from 2015 until 2019, the average period of a student's final assignment completion reaches 8 months, or in other words, it exceeds the standard that has been determined. The nonconforming completion period of those has a negative impact on the educational quality of FMIPA ULM. The nonconforming period gives less emphasis to educational quality, especially in the final assignment execution process. This implicates study program and institution accreditation evaluations. As a result, it is critical to identify the factors that influence the student's final FMIPA ULM assignment completion. The statistical method that can be used is quality control analysis to detect whether the process of final assignment completion so far is already statistically in control or fulfills the specification limit that has been determined in the curriculum.

Quality control is a system to maintain the quality level as desired [1]. Quality control is statistically done by comparing the specification result from a production process with the desired standard or determined specification. Quality improvement has the main aim of reducing the variability of processes so as to minimize products or services that do not satisfy the determined specification. If variability is low, then the product quality will improve [2]. In the educational area, quality control is required to help improve the quality of education performance as the desired standard of determining specialization. Hence, this research will analyze the quality control in students' final assignment completion period of FMIPA ULM, whether it is statistically in control using variable and attribute data, and do the process capability analysis of the process.

1.1 Introduction of Statistical Quality Control

Definition 1. *Quality is fitness of use.* [2]

Definition 2. *Quality improvement is a never ending process and effort to reduce the variability in a process and reduce the production of nonconforming product.* [3]

Definition 3. *Quality control is a system that maintaining the quality level as desired.* [4]

1.2 Data and Statistic Descriptive

Definition 4. *Mean of sample denoted as $\bar{x}$, with x_i as total of observation and n as numbers of observation.* [1]

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \; ; i = 1,2, \dots n \qquad (1)$$

Definition 5. *Range is denoted as R, with x_b as biggest observation value and x_a as smallest observation value.* [1]

$$R = x_b - x_a \qquad (2)$$

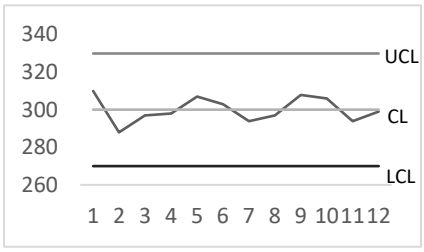
For testing the data distribution, this research will use Kolmogorov-Smirnov test which denoted as D or maximum deviation with formula as follow. [5]

$$D = \max|F_n(X_i) - F_0(X_i)|, \; i = 1,2, \dots, n \qquad (3)$$

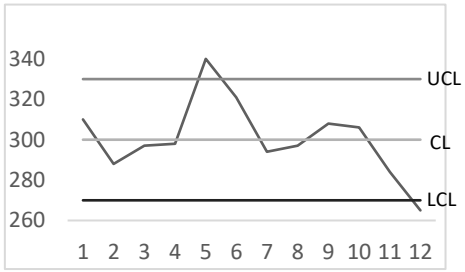
1.3 Statistical Quality Control

Statistical Quality Control is one of the statistical techniques to identify the variability sources in the production process [6]. Statistical Quality Control also known as Statistical Process Control is a useful tool in achieving process stability and improving capability through the reduction of variability [2]. Statistical Process Control uses control charts as a graphical display of a quality characteristic information.

Definition 6. *Control chart is a tool to analyze continuous and discrete data with aim to maintain the quality standard.* [7]



(a) In Control



(b) Out of Control

Figure 1. Control Chart

Definition 7. *Mean for $\bar{x}$ control chart denoted with $\bar{\bar{x}}$ and defined as follow.* [1]

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{m} \bar{x}_i}{m} ; i = 1,2, \dots, m \quad (1)$$

Definition 8. *Control limit for $\bar{x}$ control chart given as follow.* [1]

$$(UCL_{\bar{x}}, LCL_{\bar{x}}) = \bar{\bar{x}} \pm A_2 \bar{R} \quad (2)$$

Definition 9. *Mean of R control chart denoted as $\bar{R}$.* [1]

$$\bar{R} = \frac{\sum_{i=1}^{m} R_i}{m} ; i = 1,2, \dots, m \quad (3)$$

Definition 10. *Control limit for R control chart given as follow.* [1]

$$UCL_R = D_4 \bar{R} \quad (4)$$
$$LCL_R = D_3 \bar{R} \quad (5)$$

Definition 11. *Mean of p control chart for average model denoted as $\bar{p}$, defined as follow.* [1]

$$\bar{p} = \frac{\sum_{i=1}^{m} D_i}{\sum_{i=1}^{m} n_i} ; m = 1,2, \dots, m \quad (6)$$

Definition 12. *Control limit for p control chart given as follow.* [1]

$$\left(UCL_p, LCL_p\right) = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{\bar{n}}} \quad (7)$$

Definition 13. *$\hat{C}_p$ index defined as follow.* [1]

$$\hat{C}_p = \frac{USL-LSL}{6\hat{\sigma}} \quad (8)$$

Definition 14. *C_{pk} index defined as follow.* [1]

$$C_{pk} = min\left(\frac{USL-\mu}{3\sigma}, \frac{\mu-LSL}{3\sigma}\right) \quad (9)$$

Definition 15. *DPU (Defect per Unit) defined as follow.* [9]

$$DPU = \frac{Number\ of\ nonconforming}{Number\ of\ sample} \quad (10)$$

2. RESEARCH METHODS

2.1 Data and Sources

This research uses related data with students' final assignment completion process of FMIPA ULM. The secondary data was obtained from the Sub Section of Academic FMIPA ULM. The collected data is about students' final assignment completion periods of 6 study programs in FMIPA ULM from the years 2015 to 2019.

Table 1. Definition of Research Variable Operational

Data	Operational Definition	Unit	Measure
Variable data: Final assignment completion period	The time range in which students needed to finish their final assignment counted from the proposal seminar until the result seminar and/or last session.	Month	Secondary data on FMIPA ULM graduates from 2015 to 2019 was obtained from the Academic FMIPA ULM Subsection.
Attribute data: The nonconforming final assignment completion period	The nonconforming proportion of FMIPA ULM students' final assignment completion period with the determined period on the prevalent curriculum of the relevant study program.	Category: • $X \leq 6$ month = satisfy • $X > 6$ month = unsatisfy	

2.2 Research Procedures

The procedures for this research are as follows.

1. Collect data from the final assignment completion period and continue to categorize the data according to special criteria.
2. Provide statistics descriptive of the data for the final assignment completion period of FMIPA ULM.
3. Determine the control limit for each observation data point for each variable and attribute data point.
4. Provide a control chart to identify the change that occurred on the final assignment completion period's central tendency data.
5. Provide a control chart to identify the change in the final assignment completion period's measure of dispersion data.
6. Provide a control chart to identify the nonconforming proportion that happens in the process through the nonconforming data of final assignment completion period standards.
7. Take a conclusion from the data results to see if the completion of the FMIPA ULM final assignment process is statistically in control, or, in other words, if the determined period on the current curriculum is met.
8. Analyze the process capability of final assignment completion as stated statistically in control by determining the value for variable data and the DPU value for attribute data.

Take a final conclusion from data result and process capability analysis to whether the completion process of the final assignment is already statistically in control or whether it fulfills the determined time limit on the prevailing curriculum and also fulfills the specification standards.

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistic of Research Data

This research uses data about students' final assignment completion period of FMIPA ULM to identify the quality of the process of final assignment implementation. The data used in this study are bachelor alumni of FMIPA ULM from 2015 to 2019. The total number of alumni in the time range is 858 (eight hundred fifty eight). The used data is shown in Table 2 and Table 3.

Tabel 2. Alumnus Data Description by Year

Year	Total Alumnus	GPA		Length of final assignment creation (month)			Length of Study (year)		
		Mean	Range	Mean	Range	SD	Mean	Range	SD
2015	113	3.10	1.31	11.04	32.68	6.52	5.13	4.66	1.03
2016	244	3.19	1.38	9.77	33.96	4.62	4.93	5.00	0.95
2017	226	3.21	1.52	8.99	32.18	4.25	4.94	3.96	1.00

Year	Total Alumnus	GPA		Length of final assignment creation (month)			Length of Study (year)		
		Mean	Range	Mean	Range	SD	Mean	Range	SD
2018	122	3.20	1.45	9.11	19.95	4.00	5.09	4.17	1.10
2019	153	3.18	1.37	5.61	11.91	3.26	4.68	4.32	0.90

Tabel 3. Data Description of Alumnus per Study Program

Study Program	Total Data	GPA		Length of final assignment creation (month)			Length of Study (year)		
		Mean	Range	Mean	Range	SD	Mean	Range	SD
A	99	3.18	1.30	10.70	32.99	6.18	4.95	3.65	0.87
B	252	3.14	1.55	9.68	33.08	5.30	4.63	3.75	0.94
C	104	3.20	1.15	6.61	21.82	3.36	4.93	4.37	1.06
D	155	3.31	1.17	9.01	13.94	2.98	5.26	3.54	0.88
E	104	3.25	1.30	10.24	33.96	5.66	4.73	5.92	0.91
F	144	3.08	1.25	7.49	24.86	5.15	5.25	4.06	1.14

A normality test of the data is shown in Figure 1. Using the Kolmogorov-Smirnov test, the obtained result is presented in Table 4 with a confidence interval of 95% ($\alpha = 0.05$). The result is value of D is less than D Table ($0.105 < 0.242$), indicating that the data is in normal distribution.

Table 5. Average Data per Year All Study Program

	N sample	Mean	Standard Deviation	D	D Table
Average data per year of all study program	30	9.067	2.735	0.105	0.242

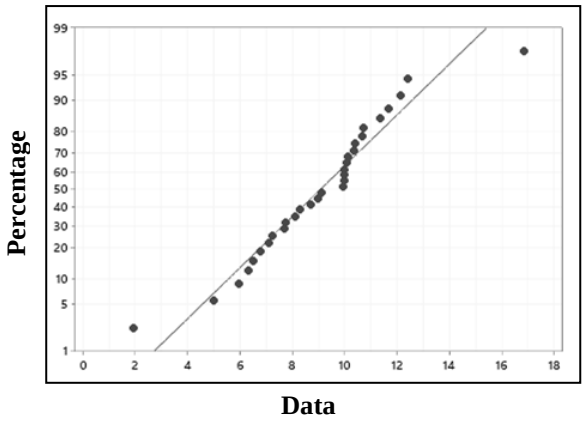


Figure 2. Normal Data Distribution of final assignment period completion per year 2015-2019

3.2. Control Limit and Control Chart

The used data for variable data is shown by Table 4 as follow.

Table 5. Average Data per Year All Study Program

Study Program	2015	2016	2017	2018	2019	$\bar{x}$	R
	x_1	x_2	x_3	x_4	x_5		
A	12.40	8.98	10.00	10.35	7.24	**9.79**	**5.16**
B	11.35	10.73	9.10	8.68	8.09	**9.59**	**3.26**
C	7.73	6.30	5.95	6.77	6.52	**6.65**	**1.78**
D	10.40	10.11	9.92	10.00	4.99	**9.08**	**5.41**
E	16.84	10.00	10.07	12.14	8.27	**11.46**	**8.57**
F	11.70	10.67	7.71	7.11	1.90	**7.82**	**9.8**
Mean	**11.74**	**9.47**	**8.79**	**9.18**	**6.17**		

For $\bar{x}$ control limit, the mean value is written by $\bar{\bar{x}}$ with upper and lower control limit that obtained as follow.

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{m} \bar{x}_i}{m} = \frac{54.50}{6} = 9.067$$
$$UCL_{\bar{x}} = 12.334$$
$$LCL_{\bar{x}} = 5.8$$

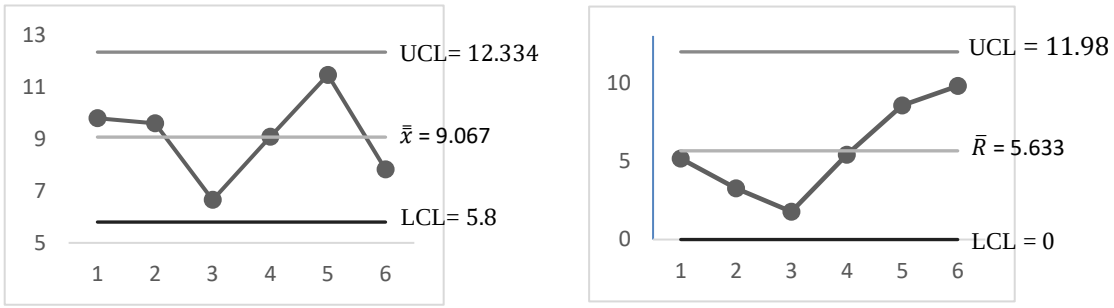
And for the mean value of R control chart is written by $\bar{R}$ with upper and lower control limit obtained as follow.

$$\bar{R} = \frac{\sum_{i=1}^{m} R_i}{m} = \frac{33.98}{6} = 5.663$$
$$UCL_R = 11.98$$
$$LCL_R = 0$$

Then we continue to attribute the data that is used in this research as a control chart or proportion control chart. The nonconforming data from a total of 858 students shows that 655 students that completed the final assignment in more than 6 months. For attribute control charts, the mean value of the control chart is written by $\bar{p}$ with upper and lower control limits as follows

$$\bar{p} = \frac{\sum_{i=1}^{m} D_i}{\sum_{i=1}^{m} n_i} = \frac{655}{858} = 0.7634$$
$$UCL_p = 1.002$$
$$LCL_p = 0.5249$$

Next, the variable control chart and attribute control chart is built using the control limits that have been obtained before. The figures for the variable and attribute control charts are shown in Figures 3 and 4 as follows.



(a) $\bar{x}$ control chart (b) R control chart

Figure 3. Variable Control Chart for Year 2015-2019

The figure above shows that the student's final assignment completion of FMIPA ULM is statistically under control based on variable data. The attribute control chart, which is shown by p control chart below, has a mean value proportion of 76.34%. Those values indicated the high proportion of students that finished their final assignment more than the determined period.

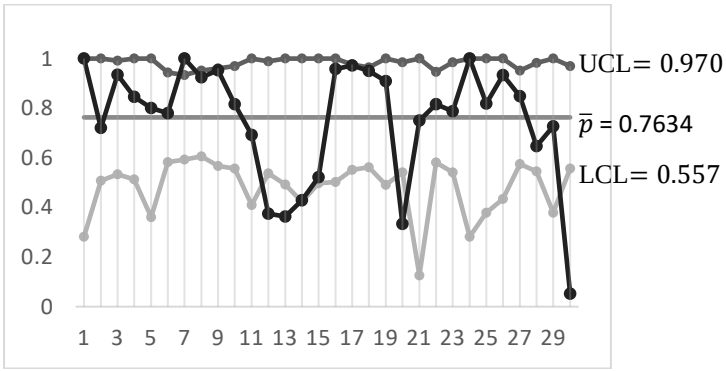


Figure 4. Attribute Control Chart Year 2015-2019

The figure above shows all the study programs with a total data value of 30. Of the 30 points, there are 5 that cross the lower control limit and 1 point that crosses the upper control limit. If it's revised, the crossed points

will be eliminated. After the third revision, the sample left is 21 points, with a central limit value of 0.8611. This control chart can be seen in Figure 5 below. The control chart shows that all points are within the control limit. In other words, the process is statistically under control. But, the average proportion that is obtained is pretty large, at 86.11 percent. This shows that the nonconforming time of the final assignment completion period is still high or does not satisfy the time specification on the prevailed curriculum yet.

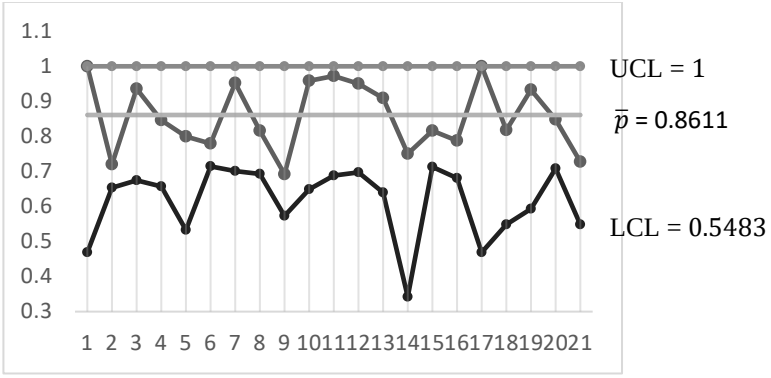


Figure 5. Revised Attribute Control Chart Year 2015-2019

3.3. Process Capability Analysis

Process capability analysis will be used for variable data and also attribute data. For variable data, the index that is used is C_p and C_{pk}, and for attribute data, the DPU of *defects per unit* will be used to analyze the process capability.

For C_p index the USL or Upper Specification Limit and LSL or Lower Specification Limit use the UCL and LCL value from $\bar{x}$ control limit as follows:

$$\hat{C}_p = \frac{USL - LSL}{6\hat{\sigma}} = \frac{12.334 - 5.8}{6 \times 2.435} = \frac{6.534}{14.61} = 0.447$$

And for C_{pk} index value is

$$\begin{aligned} C_{pk} &= \min\left(\frac{USL-\bar{\bar{x}}}{3\sigma}, \frac{\bar{\bar{x}}-LSL}{3\sigma}\right) \\ &= \min\left(\frac{12.334 - 9.067}{3 \times 2.435}, \frac{9.067 - 5{,}8}{3 \times 2.435}\right) \\ &= 0.447 \end{aligned}$$

From those calculations, the real capability index and the mean capability index are the same ($C_p = C_{pk}$). In other words, the point of observation stands at the middle point of specification. But, C_p index value is less than 1,33. It shows that the process is not capable. So as for C_{pk} also less than 1,33 which show that data of final assignment completion is not approaching the target or middle point.

Then process capability analysis for attribute data with the number of samples is 858, with nonconforming data of 655 samples. The result was obtained as follows:

$$DPU = \frac{Number\ of\ nonconforming}{Number\ of\ Sample} = \frac{655}{858} = 0.7634$$

In percentage form, it will be 76.34%. This shows that the nonconforming percentage from the final assignment completion process is very high, reaching 76%. In other words, the process is not capable of satisfying the specification yet. Overall, it can be concluded that students' final assignment completion process from the year 2015 until 2019 is not capable or has low accuracy and low relative precision within the ideal time range which has been determined in the curriculum.

4. CONCLUSION

Based on the result of the data analysis, can be concluded as.

1. The completion period of a student's final assignment of FMIPA ULM is identified as statistically in control if used as the center limit on the control chart. Along with the nonconforming proportion of final assignment completion of 86.11% as an average value, the control chart that formed shows a process that is statistically in control with a center limit of 0.8611.
2. The variable control chart for the student's final assignment completion period of FMIPA ULM from the year 2015 until 2019 was statistically in control, but the completion process is still not capable (C_p and $C_{pk} = 0.447$). In other words, the completion process itself has low accuracy and precision within the ideal time range that has been determined in the curriculum. A control chart for the nonconforming proportion of a student's final assignment completion period is also identified statistically in control. But the average proportion of nonconforming the completion period is high enough, at 76.34%, so it can be concluded as not yet capable of fulfilling the determined specification of the curriculum.

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