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Case study article

Clustering student satisfaction using SERVQUAL and K-means methods

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ABSTRACT

Student satisfaction is a critical indicator of higher education service quality. Higher education institutions must maintain student satisfaction to ensure service quality. This study measures and analyzes student satisfaction at higher education institutions using the SERVQUAL model to inform service improvement strategies. A survey assessed five key service dimensions: Tangibles, Reliability, Responsiveness, Assurance, and Empathy. Gap analysis and non-hierarchical K-means clustering identified six student groups with varying satisfaction levels. Cluster 1, with an average gap score of -3.00 and a Customer Satisfaction Index (CSI) of 65.68%, was categorized as 'less satisfied' and prioritized for improvement. Importance Performance Analysis (IPA) identified critical service attributes. Improvement strategies; developed using the 5W+1H framework (Who, What, Where, When, Why, and How); emphasize enhanced communication, faster service delivery, strengthened employee competencies, and a student-centered organizational culture. These findings provide a robust foundation for strategic decision-making to enhance service quality in higher education institutions.

1. Introduction

Sultan Ageng Tirtayasa University (Untirta) is a prominent state university in Indonesia. Located in Banten Province, Untirta operates several branch campuses in strategic areas of the region. The university has experienced significant growth annually. One of its faculties, the Faculty of Engineering, is situated in the Cilegon Industrial Area, home to major industries such as Krakatau Steel & Group, Krakatau Posco, Candra Asri, Asahimas, Tri Polita, PLN (Persero) PLTGU Cilegon, and Indonesia Power UBP Suralaya. Geographically, the Faculty of Engineering, Untirta, lies at the gateway of Java-Sumatra trade routes and international commerce. Administratively, it is located in Cilegon City within the developing Banten Province.

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Fig 1. Geographical distribution of Untirta students.

Despite these advantages, the faculty faces declining student interest. Data from 2017 to 2021 show a decrease in prospective students applying through the Joint State University Entrance Selection (SBMPTN) route. Given this trend, the management of the Faculty of Engineering, Untirta, should develop strategies to enhance competitiveness and promote the faculty to attract greater numbers of students. The faculty's diverse student body, originating from various regions and islands across Indonesia, exhibits a wide range of characteristics and perceptions. To address this diversity and the rapid dissemination of information, the faculty must implement targeted strategies to improve student satisfaction. This study aims to measure and analyze student satisfaction at the Faculty of Engineering, Untirta, providing valuable insights for the faculty's management to enhance service quality.

One of the strategies to enhance competitiveness and promote higher education institutions is improving student service quality. High-quality services foster student satisfaction, contributing to a positive institutional image [1]. Satisfaction is critical for building customer loyalty and ensuring sustainable institutional development [1]. Moreover, enhancing service quality significantly influences student motivation to excel, leading to high-quality outputs [2]. Many students at the Faculty of Engineering (FT), Sultan Ageng Tirtayasa University (Untirta), originate from diverse regions across Indonesia, including Banten Province, Lampung, Batam, Lombok, Papua, and other areas beyond Java. Fig 1 illustrates the distribution of Untirta students across Indonesia. Given the diversity of student perceptions and rapid information dissemination, the faculty's management must implement targeted strategies to improve student satisfaction.

Despite the extensive use of the SERVQUAL model in assessing service quality, few studies have integrated it with clustering techniques to address the diverse needs of students in Indonesian universities with unique regional and industrial contexts [3]. This research addresses this gap by combining SERVQUAL with K-means clustering to group students based on satisfaction gaps, offering a data-driven approach to service improvement. The study contributes by providing actionable insights for tailoring service strategies to diverse student populations and enhancing institutional competitiveness in similar higher education settings.

This study measures and analyzes student satisfaction at the Faculty of Engineering, Untirta, to provide valuable insights for management. Satisfaction is assessed using the SERVQUAL model, which evaluates the gap between student expectations and perceived performance [3]. The SERVQUAL model measures five dimensions: Reliability, Responsiveness, Assurance, Empathy, and Tangibles [4]. After measuring satisfaction, the gap score between perceived satisfaction and student expectations is calculated. Given the diverse characteristics and perceptions of Untirta's students, K-means clustering is performed to group students based on their gap scores, providing actionable insights for service improvements.

2. Literature review

Quality is a characteristic of products or services that meets or exceeds customer needs and expectations, encompassing predefined specifications or criteria outlined in contracts, such as engineering, marketing, manufacturing, and maintenance, to ensure alignment with customer requirements [5]. As a critical factor in achieving competitive advantage, quality becomes increasingly vital in intensifying global market competition driven by rapid globalization, where the free movement of capital, resources, and products across national borders demands high-quality products and services to remain competitive [6]. Service quality hinges on two primary factors: expected service and perceived service, where service quality is assessed positively if perceived service meets or exceeds expectations, but deemed poor if it falls below, highlighting the provider's need to

consistently meet customer expectations [7]. The gap analysis model, rooted in the disconfirmation approach, evaluates service quality by comparing customer expectations with perceived performance, yielding a positive perception when performance exceeds expectations and a negative one otherwise, significantly influencing customer satisfaction [8]. However, several gaps in service delivery can lead to dissatisfaction, underscoring the importance of effective gap analysis to identify and address these discrepancies for improved service quality.

Cluster analysis involves grouping objects based on similar characteristics, using hierarchical or non-hierarchical methods [9]. Hierarchical methods begin by grouping two or more objects with the highest similarity, proceeding to objects with the next highest similarity, and include agglomerative (bottom-up) and divisive (top-down) approaches. In contrast, non-hierarchical methods start by specifying the desired number of clusters and perform clustering without a hierarchical process [10]. An example of a non-hierarchical method is K-means clustering, a data mining technique that groups data into partitions through an unsupervised process. K-means aims to minimize within-cluster variation while maximizing between-cluster variation, ensuring that data within a cluster share similar characteristics and differ from data in other clusters [11]. Clustering quality is assessed using the Within-Cluster Sum of Squares (SW) and Between-Cluster Sum of Squares (SB) values. The SW value, calculated as the sum of squared distances between each data point and its cluster center, measures within-cluster variability; lower SW values indicate denser clusters. The SB value, calculated as the sum of squared distances between cluster centers and the global mean, measures between-cluster variability; higher SB values indicate more distinct clusters [11]. The SB/SW ratio evaluates clustering quality, with a higher ratio indicating better separation between clusters relative to within-cluster variation. However, no universal threshold exists for determining optimal clustering quality, and the number of clusters must be carefully selected [11]. Comparative studies show that the non-hierarchical K-means method outperforms hierarchical methods in terms of performance, as evidenced by SW and SB values [12], [13]. Therefore, this study employs K-means clustering to group students at the Faculty of Engineering (FT), Sultan Ageng Tirtayasa University (Untirta), based on their perceptions and satisfaction with faculty services.

3. Material and method

Data for clustering research on student satisfaction at the Faculty of Engineering (FT), Sultan Ageng Tirtayasa University (Untirta), were collected through a questionnaire developed based on a literature review conducted online and offline at the FT Untirta library. The questionnaire was distributed to active FT Untirta students, with samples selected using proportionate stratified random sampling. This technique involved drawing samples from a heterogeneous, stratified population, with the sample size from each subpopulation proportional to its size, ensuring a representative sample based on population characteristics. The study examined service quality across five dimensions, as defined by Zeithaml et al. [4]: Tangibles, encompassing physical facilities, equipment, and staff appearance; Reliability, the ability to deliver promised services accurately and dependably; Responsiveness, the willingness to provide prompt and effective assistance to customers; Assurance, the competence, courtesy, and trustworthiness of staff that instill customer confidence; and Empathy, the ability to understand and address individual customer needs with care and attention.

3.1. Servqual gap calculation and analysis

After collecting questionnaire data from students, the SERVQUAL gap score was calculated by subtracting perceived service from student expectations for each dimension. These scores were subsequently processed for clustering using K-means clustering. Prior to clustering, the optimal number of clusters was determined based on the Silhouette Coefficient.

3.2. Servqual gap calculation and analysis

Once the optimum number of clusters was determined, cluster analysis was carried out using the non-hierarchical K-Means method via R Programming software, resulting in several student clusters. After these clusters were formed, a priority cluster was determined, identified as the cluster exhibiting the lowest average satisfaction gap value. The next step involved calculating the satisfaction index for the priority cluster using the Customer Satisfaction Index (CSI) method, based on questionnaire data collected through the Service Quality (Servqual) dimensions. Following this, an Importance-Performance Analysis (IPA) was performed on the priority cluster to pinpoint attributes needing improvement. As a final step, after obtaining the improvement attributes,

5W+1H interviews and brainstorming sessions were conducted with the Deputy Dean 2 of the Untirta Faculty of Engineering to develop recommendations for improvement strategies.

4. Results and discussion

In the data collection stage, data regarding service attributes reflecting customer (student) needs and expectations were gathered through a questionnaire administered to active students at the Faculty of Engineering, Untirta. The questionnaire was designed based primarily on the Servqual dimensions. From the questionnaire responses, student ratings concerning the importance and satisfaction levels were obtained for the services provided by the Untirta Faculty of Engineering, measured using a Likert scale. At the time of the study, the active student population at the Faculty of Engineering, Untirta, comprised 3,134 students across seven distinct study programs: Mechanical Engineering, Chemical Engineering, Industrial Engineering, Information Engineering, Metallurgical Engineering, Electrical Engineering, and Civil Engineering. The Cochran formula was used to determine the required sample size.

Based on the known population of 3,134 students, the Cochran formula was used to calculate the required sample size, resulting in an adjusted sample size of 343 students. This sample was then proportionally allocated across each study program at the Faculty of Engineering, Untirta. The resulting sample distribution per study program was as follows: Informatics Engineering (20 students), Electrical Engineering (58), Industrial Engineering (56), Chemical Engineering (51), Mechanical Engineering (50), Metallurgical Engineering (49), and Civil Engineering (59).

Data processing involved several steps. First, the preliminary survey instrument was tested for validity and reliability. Once its validity and reliability were confirmed, the full survey was administered to collect data from the entire respondent sample. Subsequently, Servqual Gap analysis was performed for each dimension. These Gap analysis results were then clustered using the K-Means method, ultimately forming student clusters based on their dimensional Gap values.

The validity test for the expectation statement attributes assessed whether the questionnaire effectively measured the perceived level of importance across the specified dimensions (tangibles, reliability, responsiveness, assurance, empathy). The results of this validity test for expectations are presented in Table 1. Table 1 indicates that the validity test for all expectation items across the five dimensions (tangibles, reliability, responsiveness, assurance, and empathy) yielded significance values (Sig.) of 0.000. Since these values are less than the significance level (α = 0.05), all items are concluded to be valid.

Table 1
Validity test

Dimension	Label	N	Sig.	Results
Tangibles	X1	30	0	Valid
	X2	30	0	Valid
	X3	30	0	Valid
	X4	30	0	Valid
Reliability	X5	30	0	Valid
	X6	30	0	Valid
	X7	30	0	Valid
	X8	30	0	Valid
	X9	30	0	Valid
Responsiveness	X10	30	0	Valid
	X11	30	0	Valid
	X12	30	0	Valid
	X13	30	0	Valid
Assurance	X14	30	0	Valid
	X15	30	0	Valid
	X16	30	0	Valid
	X17	30	0	Valid
Empathy	X18	30	0	Valid
	X19	30	0	Valid
	X20	30	0	Valid
	X21	30	0	Valid
	X22	30	0	Valid

Table 2
Assumption test

No	Variabel	MSA (Anti-image correlation)
1	Average gap value of Tangibles	0,566
2	Average gap value of Reliability	0,578
3	Average gap value of Responsiveness	0,612
4	Average gap value of Assurance	0,510
5	Average gap value of Empathy	0,514

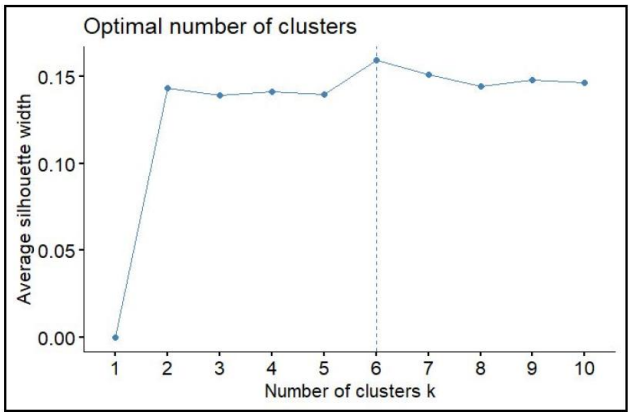

Fig 2. Optimal number of clusters obtained from Silhouette method.

Reliability testing was conducted to measure the consistency of respondents' answers to the questionnaire items. Cronbach's alpha, used as the reliability parameter, yielded a value of 0.987 for both the expectation statement attributes and the performance statement attributes. As both values significantly exceed the common threshold of 0.700, it was concluded that both the expectation and performance sections of the questionnaire demonstrate high reliability and are suitable for measuring their respective constructs. Assumption tests were performed to assess the suitability of the data for subsequent analysis (e.g., factor analysis). Bartlett's Test of Sphericity was significant (Sig. = 0.000, $p < 0.05$), indicating sufficient inter-correlation among the variables and the correlation matrix was not an identity matrix. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded a value of 0.672, exceeding the recommended minimum of 0.50, confirming the data's suitability for analysis. Additionally, the Measure of Sampling Adequacy (MSA) was examined for each individual variable using the anti-image correlation matrix. This test identifies specific variables potentially unsuitable for inclusion (typically those with MSA < 0.50), which would then be considered for elimination. The detailed MSA results for each variable are presented in Table 2. As indicated by the Measure of Sampling Adequacy (MSA) results (derived from the anti-image correlation matrix), the MSA values for all five variables were above the minimum threshold of 0.50. Therefore, all variables met the requirement for sampling adequacy and were retained for further analysis, with no variables needing elimination.

Prior to performing the cluster analysis in this study, the optimal number of clusters was determined using the Silhouette, Elbow, and Gap Statistic methods. This determination was performed using RStudio software. Fig 2 presents the results obtained from the Silhouette method for identifying the optimal cluster count. The average Silhouette value was used to evaluate the quality of different cluster solutions, where higher average values indicate better cluster structures. Based on the Silhouette analysis, the highest average Silhouette score occurred when the number of clusters k was 6. Therefore, the Silhouette method suggested that the optimal number of clusters for this dataset is 6.

Student cluster visualization was generated using RStudio software, typically plotting the first two principal components (PCA: dim1 and dim2). Although these first two components explained a relatively low percentage of the total variance, and the resulting 2D visualization in Fig 3 showed considerable overlap between clusters, this is often expected with complex, high-dimensional data. Such visual overlap does not necessarily indicate a failure in the clustering analysis itself but rather reflects the limitations of representing multi-dimensional data in two dimensions. Visualization using the first two principal components can still offer a useful general representation of the clustering patterns. However, exploring a three-dimensional visualization in Fig 4 might provide a more comprehensive perspective and potentially reveal clearer distinctions between cluster members that appear merged in the 2D plot.

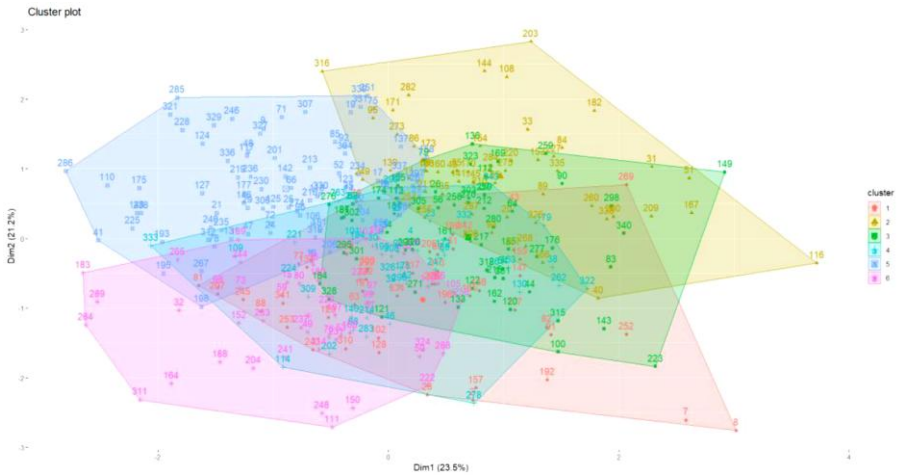

Fig 3. Visualization of clustering.

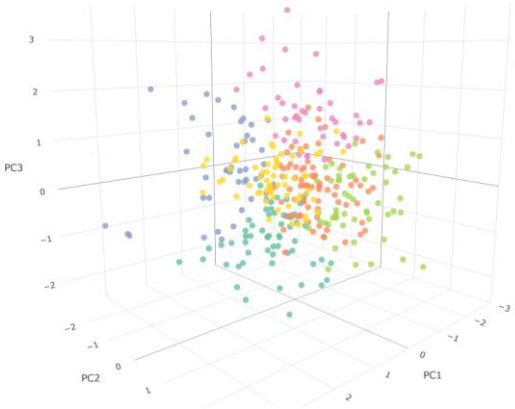

Fig 4. Cluster formation.

Table 3
Characteristics of student clusters

Cluster	Tangibles	Reliability	Responsiveness	Assurance	Empathy	Average gap per cluster
1	-0.968	-0.187	-0.723	-0.298	-0.826	-3.002
2	0.304	0.221	-0.683	-0.424	-0.025	-0.607
3	4	-1.308	-0.174	-0.194	0.583	2.907
4	3.795	3.886	3.75	3.682	4.091	19.205
5	4.079	3.573	4.157	3.528	4.112	19.449
6	4.102	3.408	4.327	3.224	4.265	19.327

Three-dimensional visualization offers multiple viewing angles, aiding the assessment of cluster formation quality. This perspective can illustrate the separation of clusters along the three principal dimensions (dim1, dim2, and dim3) and the spatial distribution of their members. Based on the completed clustering analysis, detailed characteristics for each cluster were derived and are presented in Table 3. Table 3 reveals the distinct characteristics of the six student clusters:

1. Cluster 1: Consists of students dissatisfied across all five Servqual dimensions (tangibles, reliability, responsiveness, assurance, and empathy). Given this profile, Cluster 1 was identified as the priority group for further satisfaction analysis and for determining key areas for improvement.
2. Cluster 2: Comprises students dissatisfied specifically in three dimensions: responsiveness, assurance, and empathy.
3. Cluster 3: Includes students dissatisfied specifically in three dimensions: reliability, responsiveness, and assurance.

4. Clusters 4, 5, and 6: These clusters group students who expressed satisfaction across all five Servqual dimensions.

Based on the cluster characteristics previously described, Cluster 1 represents students dissatisfied across all service dimensions. Furthermore, Table 3 confirms that Cluster 1 exhibited the lowest sum of average gap values (-3.002). Consequently, this cluster was designated as the priority group for the subsequent calculation of its satisfaction index and the identification of priority attributes for improvement. Following the identification of Cluster 1 as the priority group, its members' satisfaction level was measured using the Customer Satisfaction Index (CSI) method. The CSI calculation for Cluster 1 students, derived from their questionnaire responses, is presented in Table 4. Table 4 presents the calculation of the Customer Satisfaction Index (CSI) for Cluster 1, resulting in a score of 65.68%. Based on the established CSI interpretation scale for this study [or reference the source of the categories], this value categorizes Cluster 1 students from the Faculty of Engineering, Untirta, as "less satisfied". This finding reinforces the selection of Cluster 1 as the priority group for subsequent analysis focused on identifying specific attributes requiring improvement and developing targeted strategies.

Table 4
CSI results

Dimension	Atribut	MIS	MSS	WF	WS
Tangible	X1	4.34	3.426	0.051	0.174
	X2	4.383	2.957	0.051	0.152
	X3	4.34	3.511	0.051	0.179
	X4	4.213	3.511	0.049	0.173
Reliability	X5	3.702	3.447	0.043	0.15
	X6	3.787	3.617	0.044	0.161
	X7	3.681	3.468	0.043	0.15
	X8	3.723	3.532	0.044	0.154
	X9	3.723	3.617	0.044	0.158
Responsiveness	X10	4.021	3.17	0.047	0.149
	X11	3.809	2.957	0.045	0.132
	X12	3.957	3.255	0.046	0.151
	X13	3.83	3.34	0.045	0.15
Assurance	X14	3.681	3.489	0.043	0.151
	X15	3.511	3.468	0.041	0.143
	X16	3.723	3.34	0.044	0.146
	X17	3.745	3.17	0.044	0.139
Empathy	X18	3.851	3.085	0.045	0.139
	X19	3.745	2.553	0.044	0.112
	X20	3.787	2.851	0.044	0.127
	X21	3.936	3.489	0.046	0.161
	X22	3.787	3	0.044	0.133

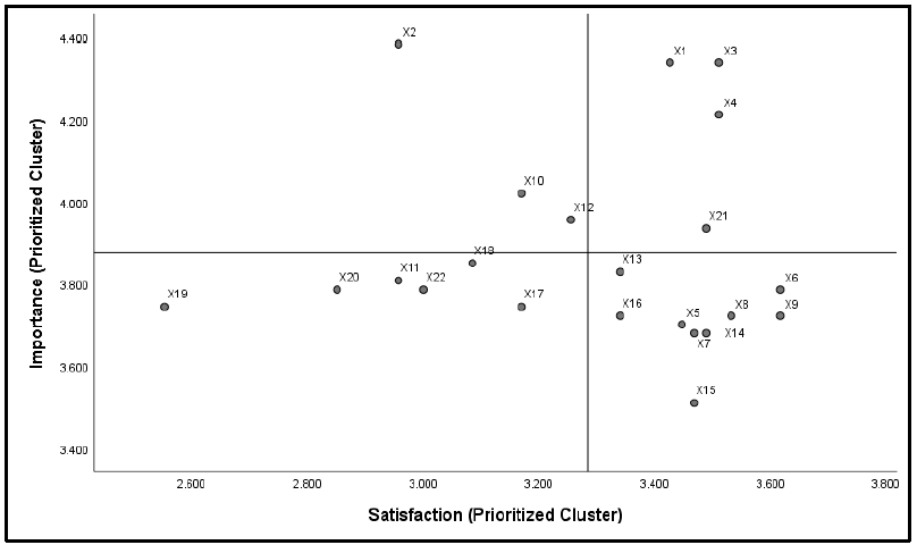

Fig 5. Priority cluster.

Table 5
IPA analysis of Cluster 1 students

Dimensions	Attribute	Information
Tangibles	X2	FT Untirta's visually appealing facilities create an inspiring learning environment.
Responsiveness	X10	FT Untirta specifies exact service times, helping students organize their activities.
	X12	FT Untirta employees consistently help students meet their needs and solve problems.

To identify specific priorities for enhancing service quality, Importance-Performance Analysis (IPA) was employed. This method compares student perceptions of the importance of service attributes with their assessment of the Faculty of Engineering Untirta's performance on those same attributes. Given the "less satisfied" CSI score of 65.68% for Cluster 1, IPA provides a framework for pinpointing areas where performance improvements are most needed, particularly concerning attributes deemed highly important by students. The results of this IPA for Cluster 1 are presented visually in the Cartesian diagram in Fig 5. As shown in Fig 5, three attributes fall into Quadrant 1. This quadrant is designated the main priority because it contains attributes that students deem highly important, yet the Faculty of Engineering Untirta's performance on these attributes is perceived as low [or unsatisfactory / below expectations]. The specific attributes located in this high-priority quadrant are listed in Table 5.

5. Conclusions

Based on the clustering analysis using the SERVQUAL and K-means methods, six clusters were identified, describing the characteristics of student satisfaction with services at the Faculty of Engineering (FT), Sultan Ageng Tirtayasa University (Untirta). Cluster 1, with the lowest average satisfaction gap score of -3.002, is the priority for improvement, as students are dissatisfied with all service dimensions (tangibles, reliability, responsiveness, assurance, empathy). This cluster, primarily male students (68.1%) from the 2021 cohort and mostly from the Industrial Engineering program (11 students), has a Customer Satisfaction Index (CSI) of 65.68%, categorized as "less satisfied." Priority attributes for improvement include Attribute X2 (visually appealing facility designs), Attribute X10 (clear service scheduling information), and Attribute X12 (employee willingness to assist students). Improvement strategies, based on the 5W+1H framework, involve developing effective communication systems, enhancing employee proactivity, and engaging students in facility design, implemented through training, policy enhancements, and management commitment. These measures are expected to enhance service quality, student satisfaction, and the overall learning experience at FT Untirta.

Declaration statement

Akbar Gunawan: Conceptualization, Methodology, Writing-Original Draft. **Nuraidha Wahyuni**: Conceptualization, Data curation, Formal analysis. **Habibie Urfa Wibowo:** Investigation, Methodology, Software. **Aditya Rahadian Fachrur**: Collecting data, Validation **Putiri Bhuana Katili, Dhena Ria Barleany**: Writing-Review & Editing.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

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