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Improving Service Quality Using Servqual With 3 Fuzzy Numbers
(A Study in ITESA Muhammadiyah Semarang)

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Abstract. *Ensuring the delivery of high-quality public services within educational institutions is a critical factor for sustaining student satisfaction, institutional reputation, and overall organizational credibility. Service quality in higher education is often multidimensional and subjective, making its evaluation a challenging process. To address this complexity, the present study integrates the traditional Servqual model with fuzzy logic in order to handle the uncertainty and vagueness associated with human perceptions. The Servqual framework emphasizes five core dimensions of service quality, namely tangibles, reliability, responsiveness, assurance, and empathy, which together provide a comprehensive understanding of institutional service performance. The research was conducted at ITESA Muhammadiyah Semarang, where data collection was carried out through structured questionnaires designed to measure both student expectations and actual perceptions regarding institutional services. In order to capture the imprecise nature of these responses, three types of fuzzy numbers—triangular, trapezoidal, and shoulder fuzzy numbers—were applied to convert the linguistic assessments into measurable values. Subsequently, fuzzy gap analysis was performed to evaluate the discrepancy between expectations and perceptions across the five Servqual dimensions. The results of this analysis highlight that the integration of fuzzy logic into the Servqual model provides a more nuanced and flexible framework for assessing service quality compared to the conventional approach. It reduces the ambiguity in interpreting survey responses, thereby yielding more reliable insights into areas where service performance falls short of expectations. Furthermore, the study demonstrates that each dimension contributes differently to overall satisfaction, with responsiveness and assurance emerging as critical aspects requiring attention. In conclusion, the fuzzy-based Servqual model offers a robust methodological advancement in evaluating service quality within educational settings. The findings not only inform institutional leaders about current performance gaps but also provide actionable insights for continuous quality enhancement, policy formulation, and strategic decision-making to strengthen institutional competitiveness and credibility.*

Keywords: *Customer Satisfaction; Fuzzy Servqual; Performance Evaluation; Public service; Student*

1. INTRODUCTION

Public organizations are expected to provide services that prioritize quality and efficiency to ensure customer satisfaction. Poor service delivery can lead to significant losses for customer in terms of time (Siahaan & Mansyur, 2023), effort, and financial resources. In the context of education, students are regarded as the customers who directly experience the services offered by educational institutions. It is essential for educational institutions to consistently enhance their service delivery to align with the changing needs and preferences of their customers (Agbonifoh & Dania, 2025). Periodic evaluations not only help identify gaps in service delivery but also provide the insights for continuous improvement, ensuring the institution remains accountable and responsive to student needs.

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Nurcholis in (Gayatri et al., 2013) listed the various functions, across sectors, that public services conduct, includes: education, healthcare, religion, environment, recreation, social, housing, funerals, drinking water, legality. Some of research has been established in the education field. The level of satisfaction of library services, according to (Agustina et al., 2020), is determined using the service quality method which measures the gap between the expected and the actual service received by users. The level of satisfaction for student service quality in education was analyzed using serve quality method and descriptive statistics by (Hasan, 2019). Meanwhile, in (Wati & Riana, 2016) the level of student satisfaction has been measured by using the combination between serve quality method and fuzzy theory. The study in (Wibowo & Nuryanto, 2022) measure the customer satisfaction of public service users by integrating the servqual model and the cartesian diagram model, which is completed with the study case in Shipping Polytechnic of North Sulawesi. Research on education has focused on topics such as educational quality, access to education, and educational equity (Mindaugas et al., 2023). The other examples of research about service quality outside the educational field has been conducted in the field of healthcare services (Sutinah & Simamora, 2018) and tax (Harinoto, 2015).

The servqual model is a widely used measure of service quality in a variety of service industries and applied in several countries (Al-Otaibi et al., 2013). This model is based on comparing customer's expectations of services with their actual experiences. Service quality model analyzed five dimensions, namely tangibles (physical evidence), reliability, responsiveness, assurance, and empathy. Service quality is measured by looking at the gap between the expected service quality and received by users (Agustina et al., 2020). Service quality model widely used in many public sectors to measure the level satisfaction. The model is also combined by other method such as descriptive statistic (Hasan, 2019), integrating the servqual model and the cartesian diagram model (Wibowo & Nuryanto, 2022), or combining it with fuzzy theory (Kartika & Suprayogi, 2017; Sutinah & Simamora, 2018; Wati & Riana, 2016). Servqual model mainly depends on a Likertscale-based questionnaire by which service quality is evaluated according to the obtained perception and expectation scores (Behdioğlu et al., 2019). The calculation can be inaccurate because these judgements must be expressed in numbers eventually. Fuzzy logic is an efficient method for dealing with situations that involve uncertainty (Firdaus et al., 2020). Hence, combining servqual model with fuzzy theory will gain more flexibility to face uncertainty problem and get more accurate result.

In this study, simulated data is used to representing actual conditions (Aulia et al., 2025). The three fuzzy number servqual method is used to evaluate student satisfaction of

provided services in ITESA Muhammadiyah Semarang. As a newly established institution focused on technology, statistics, and business, ITESA Muhammadiyah Semarang strives to continuously improve its academic and infrastructural service quality to support institutional development. Improving performance on the right attributes will increase satisfaction of public service users. Indeed, service quality in the public sector is a complex and multi-dimensional concept that is challenging to measure and evaluate (Mindaugas et al., 2023). The human factor holds the greatest contribution so that the quality of service is more difficult to imitate compared to product quality and price (Harinoto, 2015). Evaluating public service quality is a challenging task due to the diverse nature of public services and their various stakeholders (Mindaugas et al., 2023). By using servqual as a tool, the service quality can be modelled in five dimensions. Questionnaire will be used to obtained the satisfaction value for perception and expectation student. Then proceed to change the value into three fuzzy numbers. Defuzzification initiated to convert the fuzzy number into single value on each dimension. The difference between these expected and perceived value can be used as a reference to arrange the service improvement priority. The attributes of services that are already good can be maintained.

2. LITERATURE REVIEW

The fuzzy servqual model is already well-known method for analyzing public service statisfaction in many sectors. This method integrating two theories namely service quality model and fuzzy theory.

A. Servqual Model

The servqual method is a method commonly used to measure the level of service quality in the marketing field by finding a gap between the expectations and perceptions of service users (Agustina et al., 2020). The servqual method includes five aspects of service quality. Those attributes are tangibles, reliability, responsiveness, assurance, and empathy.

The first is tangibles, consisting of the quality of tangible aspects of a service, such as physical office infrastructure, the use of computerized administration, the availability, and conditions of waiting rooms. The second is reliability, which refers to the ability and capability of the institution to provide reliable services. The third is responsiveness, referring to the ability of the institution and its employees to assist and provide customers with expeditious and accurate services, as well as responding to the wants of customers (Gayatri et al., 2013). The fourth is assurance, with refers to staff's ability to build trust and confidence with knowledge

and courtesy. The last is empathy, means a sincere care and individual attention to customers that the organization provides (Behdioğlu et al., 2019).

According to (Harinoto, 2015), two factors that influenced service quality includes expected and perceived service. The gap is derived from difference between expected and perceived value. Based on the gap value, the service improvement priority can be arranged.

B. Fuzzy Theory

Fuzzy logic is commonly used for helping customer giving more objective value by analyzing the ambiguous value (Wahyudi, 2017). Making decisions about processes that contain uncertainty, such as the uncertainty in linguistic, has been shown to be less than perfect. Fuzzy logic introduced by Lotfi A. Zadeh (1965) who coined that membership is a way to make decision when faced with the problem of uncertainty (Firdaus et al., 2020). The foundation of fuzzy logic is fuzzy set theory, in which the degree of membership determines the presence of an element in a set (Zakiaturrahmah et al., 2020).

A fuzzy set is a set containing elements that have varying degrees of membership in the set. Elements of a fuzzy set are mapped to a universe of membership values using a function-theoretic form (Ross, 2004). This function maps elements of a fuzzy set to a degree of membership, which is a real numbered value on the interval 0 to 1. A fuzzy representation can be done using the membership function. The membership function is a curve that shows the mapping of data input points into membership values (often also called membership degrees) which have intervals between 0 and 1 (Wulandari & Sulistijanti, 2023). Some choices membership functions are right-left shoulder, triangular, and trapezoidal membership function. The "shoulder" of the function controlled by parameter k_2 for the right shoulder function and parameter k_1 for the left shoulder function.

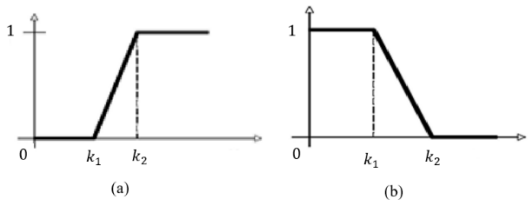

Figure 1. Membership Function: (a) Right Shoulder; (b) Left Shoulder

The triangular membership function is a function of a vector, x, and depends on three scalar parameters, k_1, k_2, and k_3 (Princy & Dhenakaran, 2016). Parameter k_1 and k_3 as the base resting on x axis ($y = 0$) and parameter k_2 determine the apex resting on the line $y = 1$. The trapezoidal membership function is a function that depends on four scalar parameters, k_1,

k_2, k_3, and k_4. Parameter k_1 as a lower limit, k_2 as a lower support limit, k_3 as an upper support limit, and k_4 as an upper limit (Princy & Dhenakaran, 2016).

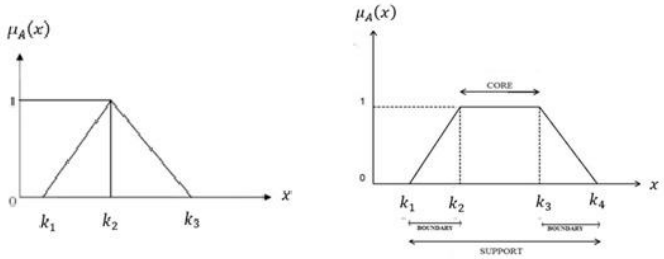

Figure 2. Triangular and Trapezoidal Membership Function

Fuzzy logic is integrated by doing fuzzification and defuzzification (Wahyudi, 2017). Fuzzification is the process of transforming the crisp set into fuzzy set to determine the fuzzy number as an output. Defuzzification is the process of converting a fuzzy set into a crisp set. An element x is either a member of crisp set A or not (Ross, 2004). This binary issue of membership can be represented mathematically as follow

$$\chi_A(x) = \begin{cases} 1 & x \in A \\ 0 & x \notin A \end{cases}$$

The result of the defuzzification will be the single value. Fuzzy methodology is conducted as linguistic input, fuzzification, fuzzy output, defuzzification and crisp output. All of sequence is implemented for every linguistic input of expected and perceived service data (Behdioğlu et al., 2019).

C. Fuzzy Service Quality

Fuzzy service quality method is a procedure to measure service quality by using of servqual model and fuzzy theory, based on five aspects dimension. Those are tangibles, reliability, responsiveness, assurance, and empathy. There are sequentially steps for fuzzy servqual method.

First step is analyzing the problem and design the questionnaire. The problem is defined as measuring and evaluating student satisfaction status regarding provided facility and service. The questionnaire consists of two parts. The first part includes five aspects of servqual model to evaluate the perception of student. The second part is about the student expectation. The student's perceptions and expectations can be obtained by linguistic variables. The linguistic variables are measured by scale 1 ("very dissatisfied") to 5 ("very satisfied"). Second step is determining the value of the perceptions and expectations linguistic variables by using linkert scale to get the value of crisp. Measurement scale used between 0 to 10.

Table 1. Linguistic Scale Measurement

Linguistic	Domain	Range
Very Dissatisfied	0-2	[0,1,2]
Not Satisfied	2-4	[2,3,4]
Quite Satisfied	4-6	[4,5.6]
Satisfied	6-8	[6,7,8]

Third step is fuzzification of input values using the overall effectiveness measure method. The result is the value of lower limit, middle limit, and upper limit, which is perform as triangular fuzzy number. The calculation is done by the measure average weight of all variables using the arithmetic mean. Fourth step is defuzzification using CoA (Center of Area) method to get a crisp value from the average weight of each variable. The crisp value can be calculated using following equation.

$$X = \frac{x.a + x.b}{a + b}$$

Last step is calculating the gap value per attribute by finding the average of the statement indicators of each attribute.

3. MATERIAL AND METHOD

A. Data Source

The data used in this research are the results of a questionnaire that measures student expectations in ITESA Muhammadiyah Semarang for the next 1-2 years. The survey was conducted from July 2 to July 19, 2024, with the participation of satisfaction and expectations from ITESA Muhammadiyah students as many as 39 students with 19 service attributes.

B. Research Variable

The research variables were obtained based on questions regarding the service process carried out by ITESA Muhammadiyah, divided into 5 (five) servqual dimensions including: Tangible, Reliability, Responsiveness, Assurance, and Empathy. The answer score from the student satisfaction and hope questionnaire is a likert scale from 1 to 5 which indicates the satisfaction level of Very Dissatisfied to Very Satisfied. Question variables as in the table 2.

Table 2 Question Variables

Servqual Dimensions	Question Number	Question
Tangiable	P1	The appearance of the lecture building is clean and comfortable

Servqual Dimensions	Question Number	Question
	P2	Adequate lecture space
	P3	The lecture room is clean and tidy
	P4	Lecturers are neat and polite
	P5	Have adequate lecture service facilities/means (for example: computers, wifi, etc.)
Reabilitas	P6	The campus provides the information needed/required by students
	P7	Lecturers understand and provide information well and clearly.
	P8	Lecturers show sincerity in serving.
	P9	Has a good information desk service system for the public and students
Responsiveness	P10	Lecturers are willing to help students in the tridharma of higher education.
	P11	Officers/Employees convey information quickly, completely, responsively and accurately.
	P12	Lecturers provide sufficient teaching time to students.
Assurance	P13	Lecturers have skills and professionalism in providing teaching.
	P14	Students feel safe and comfortable in communicating with lecturers.
	P15	Lecturers can be trusted regarding the quality of their work
	P16	Lecturers provide good attention and service when students ask questions.
Empathy	P17	Lecturers are willing to understand students' desires and difficulties.
	P18	Lecturers pay attention to the problems faced by students.
	P19	Officers/Employees pay attention to the problems faced by students.

C. Fuzzy Servqual

This research integrates two methods, namely the Fuzzy method to describe input space in the output space and the Servqual method to evaluate service quality. This method functions to reduce subjectivity in data obtained from the SERVQUAL method. This process is carried out by forming a membership function using triangular fuzzy numbers as a measure of customer perceptions and expectations. In addition, the calculation of the weighted SERVQUAL value and assessment of the level of importance of each criterion was also carried out. The stages in carrying out SERVQUAL fuzzification are as follows:

a. The data that has been collected with the Likert scale will then be calculated using the fuzzy servqual method.

b. Determine the scores for the categories that will be used in assessing respondents by utilizing fuzzy set values.
c. Fuzzification of customer satisfaction and expectation questionnaire data. The calculation is carried out by determining the lower limit to the upper limit of the interest value
d. Defuzzification, namely describing a single, representative value with the criteria in question.

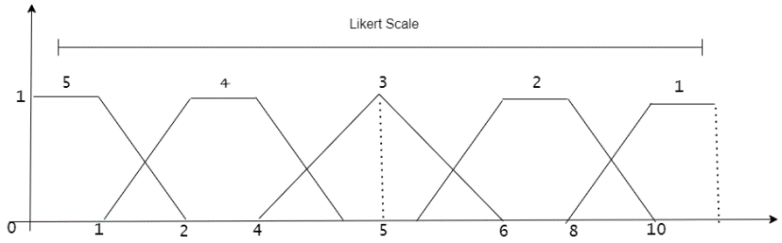

Figure 3. Fuzzy Servqual

4. RESULTS AND DISCUSSION

Based on the questionnaire and the results of the calculation, ITESA Muhammadiyah Semarang has the following service quality assessment results.

Table 3. Gap from Deffuzyfication Process

Variable	GAP	INFORMATION
	TANGIBLE	
P1	1,44298245614035	On average overall, the tangible dimension has a Satisfaction rating, and is ranked 4th on the priority for improvement
P2	1,52631578947368	There is a P4 dimension (Lecturers with a neat and polite appearance) that must be corrected immediately because it has a dissatisfied score
P3	0,951754385964912	The second priority for improvement is in P3 (clean and tidy lecture rooms)
P4	-0,171052631578948	The third priority for improvement is in P1 (Clean and comfortable appearance of the lecture building) The fourth priority for improvement is in P2 (adequate lecture room)
	REABILITY	
P5	0,723684210526316	On average, the realibility dimension has a Satisfaction rating, and is ranked 2nd on the priority for improvement
P6	1,21929824561404	There is a P8 dimension (Lecturers show seriousness in serving) that must be corrected immediately because they have dissatisfied scores
P7	0,837719298245614	The second priority for improvement is in P5 (Having adequate lecture facilities/facilities (e.g. computers, wifi, etc))
P8	-0,00877192982456077	The third priority for improvement is in P7 (Students understand and provide information well and clearly.) The fourth priority for improvement is in P6 (The campus provides the information needed/needed by students)
	RESPONSIVENESS	
P9	0,964912280701754	On average overall, the ressponsive dimension has a Satisfied rating, and is ranked 5th on the priority of improvement
P10	0,337719298245614	P10 first improvement priority (Lecturers are willing to help students in the tridharma of higher education)

P11	1,51315789473684	The second priority for improvement is in P9 (Having a good information desk service system for the public and students) The third priority for improvement is in P11 (Officers/Employees convey information quickly, completely, responsively, and accurately.)
	ASSURANCE	
P12	0,0219298245614041	On average, the assurance dimension has a Satisfaction rating, and ranks 1st on the priority of improvement
P13	0,267543859649122	P12 first improvement priority (Lecturers provide sufficient teaching time to students) The second priority for improvement is in P13 (Lecturers have skills and professionalism in teaching.)
P14	0,49561403508772	The third priority for improvement is in P15 (Lecturers can be trusted regarding the quality of their work)
P15	0,381578947368421	The fourth priority for improvement is in P14 (Students feel safe and comfortable in communicating with lecturers.)
	EMPATHY	
P16	0,421052631578947	On average, the empathy dimension has a Satisfaction rating, and is ranked 3rd on the priority of improvement
P17	0,684210526315789	P16 first improvement priority (Lecturers provide good attention and service when students ask questions.)
P18	1,01315789473684	The second priority for improvement is in P17 (Lecturers are willing to understand the wishes and difficulties of students.)
P19	1,33771929824561	The third priority for improvement is in P18 (Lecturers pay attention to the problems faced by students.) The fourth priority for improvement is in P19 (Officers/Employees pay attention to the problems faced by students.)

From the following results, the institution needs to prioritize improving the "tangible" dimension, especially the appearance of lecturers who should look neat and polite. In the dimension of "Reability", the priority that needs to be improved immediately by the Institution is Lecturers show seriousness in serving. In the dimension of "Responsiveness", the priority that needs to be improved immediately by the Institution is Lecturers are willing to help students in the tridharma of higher education. In the dimension of "Assurance", the priority that needs to be improved immediately by the Institution is Lecturers provide sufficient teaching time to students. In the dimension of "Empathy", the priority that needs to be improved immediately by the Institution is Lecturers provide good attention and service when students ask questions.

5. CONCLUSION

The fuzzy method implemented in the service process assessment at the ITESA Muhammadiyah Semarang campus succeeded in providing information that in general the service process at the ITESA Muhammadiyah Semarang campus is good, but there are 2 things that are prioritized for service improvement, namely Lecturers with a neat and polite appearance and Lecturers show seriousness in serving.

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