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Building Sustainability of the Servqual Gap System with the 5 Dimensional Model of Physical Evidence

Johan Alfian Pradana[1]*, Alifah Nur Astari[2]

[1] *Master of Industrial Engineering, Faculty of Industrial Technology, Adhi Tama Institute of Technology Surabaya, Jl. Arief Rahman Hakim No.100, Klampis Ngasem, Sukolilo District, Surabaya, East Java, 60117, INDONESIA*

[2] *Industrial Engineering, Faculty of Engineering, Widyatama University, Indonesia Jl. Cikutra, No. 204A, Sukapada, Cibeunying Kidul, Bandung, West Java, 40125, INDONESIA*

*Corresponding Author: zoehuntz34@gmail.com
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Fuzservqual, Fuzzy Logic Mamdani, Simulink, service quality measurement system, specific needs of the organization

Abstract

The digital era demands increasingly better quality computerized education services. However, a robust service quality measurement system, especially for the physical evidence dimension, still does not exist. The current system lacks precision, efficiency and effectiveness in measuring physical evidence. This results in organizations not having sufficient information to improve service efficiency, identify areas that need improvement, and optimize resources. This research develops a more sophisticated, accurate and efficient service quality measurement system for the tangible dimension by integrating Simulink and Fuzzy Logic. This research uses a mixed method with a quantitative and qualitative design. The research sample consisted of 100 respondents. Data was collected via e-questionnaire and analyzed using Simulink and Mamdani's Fuzzy Logic Designer. This research develops a sophisticated, accurate and efficient tangible dimension service quality measurement system. This system uses Simulink and Fuzzy Logic Mamdani. The results show that customers are quite satisfied with the tangible aspects. Fuzservqual shows a value of 3.00 - 3.76 for all tangible attributes, including the "fairly satisfied" category, Superior fuzzy simulink because decimal values are more thorough. Simulink and Fuzzy Logic Mamdani produce almost the same Fuzservqual results. This integration offers an accurate, efficient and effective measurement system. This helps improve the overall quality of service. These advantages help organizations improve measurement efficiency and effectiveness, identify areas that need improvement, optimize resources, increase customer satisfaction, save time and costs, increase measurement accuracy and reliability, facilitate collaboration and system development, adapt the system to various types of services and contexts , and meet the specific needs of the organization. In the future, this study will be able to be implemented precisely, this is because it is in the simulation prototype testing model.

1. Introduction

The digital era demands increasingly better quality computerized education services. This is proven by the increasing use of technology in education, such as online learning, virtual classes and digital education platforms.

The Indonesian government, schools, universities and the public are showing enthusiasm for computerized education. This can be seen from government programs such as School Digitalization and Freedom to Learn, adoption of digital technology in schools and universities, and public awareness of the benefits of computerized education. Improving the quality of computerized education services can bring many benefits, such as wider access to education, better quality of learning, optimal learning outcomes, as well as efficiency and effectiveness in education management.

Despite high enthusiasm for computerized education services, a robust service quality measurement system is still missing, especially the physical evidence dimension. The current system has several weaknesses, such as lack of precision, efficiency and effectiveness in measuring physical evidence, such as the appearance of administrative staff, cleanliness of administrative service rooms, comfort of waiting areas, souvenirs for lucky queuers and administrative service facilities. Measurements using conventional questionnaires lack detail and are biased because the chance of human error is very high in inputting the data, log data is difficult to analyze, and observations are time consuming. As a result, organizations do not have sufficient information to improve service efficiency, identify areas for improvement, optimize resources, and increase customer satisfaction. Therefore, a more sophisticated, accurate and efficient measurement system is needed to help organizations improve the quality of computerized education services.

Medical tech is crucial for quality care in today's competitive healthcare landscape, but traditional aspects like hygiene and expertise also matter[1]. Study examines service quality gaps in Sandakphu trek using AHP-SERVQUAL model to improve tourist satisfaction[2]. This study compares various systems using a unified framework, proposing a novel fuzzy logic controller to extend fuel cell lifetime by up to 32.8%[3]. Paper reviews DC biased reactors, analyzes designs, proposes new models for improved control and optimization[4]. Fuzzy logic control system is deployed to obtain this goal. In the simulation section, a smart home with flexible appliances is scheduled[5]. Paratransit quality matters for user satisfaction, with safety, comfort, and integration being key aspects[6]. User reviews complement objective measures for better hospital recommendations using fuzzy logic[7]. MATLAB simulink model predicts soil temperature, designs efficient EAHEs, compares configurations for optimal cooling[8]. Network selection is crucial for handover management, a new method using fuzzy sets is proposed for better decision making[9]. Fuzzy logic framework improves design of elderly shoes for better fall prevention[10].

The findings here explore various aspects of service quality and user satisfaction across different fields. Here's a breakdown of the key takeaways Multiple factors affect service quality: Studies examine factors such as medical technology, hygiene, expertise, safety, comfort, responsiveness, and empathy depending on the service domain (healthcare, transportation, education etc.). Fuzzy logic is a helpful tool: Fuzzy logic is a mathematical approach to deal with vagueness and uncertainty. Many studies use fuzzy logic models to improve service quality assessment and decision-making. Different methods assess service quality: SERVQUAL and its variations are common methods to measure service quality in various sectors (higher education, banking etc.). User satisfaction is crucial: Several studies highlight the link between service quality and user satisfaction. Understanding user needs is essential for improvement. Simulations aid design and optimization: MATLAB/Simulink is a popular toolset for simulating systems and optimizing performance in various fields (electric vehicles, solar energy etc.). Overall, these findings emphasize that providing good quality service requires understanding user needs, using appropriate tools for assessment, and continuously striving for improvement.

Existing studies, (1) there is no verification of simulink & fuzzy logic [9], (2) the existing findings do not yet focus on physical evidence [7], (3) in designing fuzzy servqual no one has used simulink as a simulation methodology. Service quality studies require precise methods (fuzzy logic) & users (educational service needs). Simulink verification & physical evidence have not been researched. Fuzzy Servqual & Simulink integration for innovative service design does not yet exist[5].

This research presents a breakthrough in measuring service quality, especially the physical evidence dimension, by integrating Simulink and Fuzzy Logic. This integration offers six unprecedented advantages, namely Determining measurement detail by determining the level of Fuzservqual measurement detail precisely as needed, enabling more focused and accurate analysis. Simulation and optimization of systems that are simulated and optimized before implementation, ensuring measurement accuracy, efficiency and effectiveness, saving time and resources. System visualization with Simulink block diagrams helps understand how the system works thoroughly and makes debugging easier, increasing transparency and ease of use. Fuzzy Logic Embryos and Visual Prototypes provide a framework for building embryos and visual prototypes of systems before implementation, enabling visualization and initial validation before modeling development. Flexibility and customization because measurement systems can be designed with great flexibility and tailored to specific needs, enabling adaptation to different types of services and contexts.

This study develops a more sophisticated, accurate and efficient service quality measurement system for the tangible dimension, by integrating Simulink and Fuzzy Logic.

Simulink and Fuzzy Logic in measuring service quality are new breakthroughs that improve service quality with new opportunities for the development of more sophisticated and accurate measurement systems in the future.

This integration provides contributions in determining precise measurement details, system simulation and optimization before implementation, easy-to-understand visualization, creation of visual embryos and prototypes, as well as system flexibility and customization. These advantages help organizations improve measurement efficiency and effectiveness, identify areas that need improvement, optimize resources, increase customer satisfaction, save time and costs, increase measurement accuracy and reliability, facilitate collaboration and system development, adapt the system to various types of services and contexts, and meet the specific needs of the organization

2. Literature Review

2.1 Fuzzy Logic DesignerMATLAB R2017B

Fuzzy Logic Designer (FLD) helps decision making by processing uncertain data, and balancing the value of service systems[11], [12]. FLD improves the efficiency and accuracy of analysis and decision making, especially in the field of competitive service quality[13].

2.2 Simulink MATLAB R2017B

Simulink MATLAB R2017B plays an important role in measuring the quality of educational services by simulating models produced from Fuzzy Logic Designer.

2.3 Tangible Dimensions of Service Quality

The good quality of administrative services in education is manifested through several aspects, such as the neat, polite and communicative appearance of the staff; service rooms that are clean, comfortable and equipped with adequate facilities; a comfortable, quiet waiting area with entertainment available; souvenirs that increase satisfaction and are useful for users, as well as facilities that are equipped with adequate equipment, an orderly queuing system, and information that is easily accessible[14], [15].

2.4 Information Systems Design

This service quality measurement information system is designed using the Service Quality Gap Model 5 (Servqual GM5) framework which is reinforced with fuzzy logic to minimize bias in filling out questionnaires by respondents[2], [16]. This model, called Fuzservqual GM5, was designed in Fuzzy Logic Designer to produce a fuzzy logic model which was then integrated with Simulink to build a Fuzservqual GM5 simulation program[17]

3. Methodology

3.1 Research design

This research uses a mix method design, which is a quantitative and qualitative collaborative approach[18]. This mix method design decision was due to the need to distribute data from the e-questionnaire as quantitative analysis and the need to design the Fuzservqual GM 5 model as qualitative analysis.

3.2 Research Tools

This research uses a Lenovo Ideapad Flex 5 AMD 4000 Series Laptop with MATLAB R2017B software. Fuzzy Logic Designer programs of the Fuzzy Mamdani and Simulink Logic Designer types are used to build system models. The e-questionnaire was created on Google Form and distributed to respondents for data collection.

3.3 Operational Variables

Table 1 *Operational variables*

Dimensions	No. code	Code	Attribute	Source
	1	TGB1	Appearance of administrative staff	[19]
	2	TGB2	Cleanliness of the administrative service room	[19]
Tangibles	3	TGB3	Comfortable place to wait	[20]
	4	TGB4	*Souvenirs*for lucky queuers	Processed by researchers, 2022
	5	TGB5	Administrative service facilities	[20]

(Source: processed by researchers, 2023)

3.4 Population and Sample

The research population is an active student body of 7208 students for the 2021 odd academic year, as of July 30 2022. The sampling technique was taken, namely probability sampling with a simple random sampling model using the Slovin method.[21].

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

Where:
n = number of samples
N = total population
e = margin of error (1%-10%)
$n = \frac{7208}{1+(7208)\ x\ 0{,}1^2} = 98{,}6 \sim 100$respondents

The smallest research sample used 98.6 respondents. This is to represent the population, the sample used is rounded to 100 respondents.

3.5 Analysis Techniques

1. Designing a fuzservqual GM5 simulation in the tangible dimension using simulink with 2 constant unit components for perception variables and expectation variables, 3 scopes that function to visualize perception graphs, expectations and results from fuzservqual GM5, 1 unit bus creator to connect 2 scopes with the fuzzy logic controller, 1 for fuzzy logic controller for control of 2 scopes, 1 display unit to display GM5 fuzservqual results.
2. The results of the e-questionnaire on perceptions and expectations of the tangible dimensions were tabulated and the average score for each service quality dimension item was calculated. Then, a fuzzy number with weighting on a scale of 1 to 5 (STP - P) is determined for each item, fuzzified using the following formula.

$$a = \frac{(a_{j1}.n_{j1}) + (a_{j2}.n_{j2}) + \cdots + (a_{ji}.n_{ji})}{(a_{j1} + a_{j1} + \cdots + a_{ji})} \quad (2)$$

$$b = \frac{(b_{j1}.n_{j1}) + (b_{j2}.n_{j2}) + \cdots + (b_{ji}.n_{ji})}{(b_{j1} + b_{j1} + \cdots + b_{ji})} \quad (3)$$

$$c = \frac{(c_{j1}.n_{j1}) + (c_{j2}.n_{j2}) + \cdots + (c_{ji}.n_{ji})}{(c_{j1} + c_{j1} + \cdots + c_{ji})} \quad (4)$$

Information:
a = lower limit fuzzyfication value
b = middle limit fuzzyfication value
c = upper limit fuzzyfication value
n = number of respondents

i = criteria (1,2,3,..)
j = linguistic variable

Table 2 *Fuzzy number range*

Universe of Conversations	Perceptual Sets	Hope Set	Domain	Range FuzzyNumbers		
1-5	Very dissatisfied	Very dissatisfied	[1-2]	1,	1,	2
1-5	Not satisfied	Not satisfied	[1-3]	1,	2,	3
1-5	Quite satisfied	Quite satisfied	[2-4]	2,	3,	4
1-5	Satisfied	Satisfied	[3-5]	3,	4,	5
1-5	Very satisfied	Very satisfied	[4-5]	4,	5,	5

3. Designing defuzzification using the centroid method.

$$\text{Defuzzifikasi} = \frac{a + b + c}{3} \tag{5}$$

Table 3 *Defuzzification*

Defuzzification	Domain	Range FuzzyNumbers		
Low	[1 – 3]	1,	2,	3
Currently	[2 – 4]	2,	3,	4
Tall	[3 - 5]	3,	5,	5

4. The results of defuzzification to design membership functions in tangible dimensions were then designed into Mamdani's Fuzzy Logic Designer using MATLAB R2017B, the results of which were displayed in the Fuzzy Toolbox with the following rules.

[R1] *If Perception is* SP *and* Hope SP *then* Service Quality Level Tall
[R2] *If Perception is* SP *and* Hope P *then* Service Quality Level Tall
[R3] *If Perception is* SP *and* Hope CP *then* Service Quality Level Currently
[R4] *If Perception is* SP *and* Hope T.P *then* Service Quality Level Currently
[R5] *If Perception is* SP *and* Hope STP *then* Service Quality Level Low
[R6] *If Perception is* P *and* Hope SP *then* Service Quality Level Tall
[R7] *If Perception is* P *and* Hope P *then* Service Quality Level Tall
[R8] *If Perception is* P *and* Hope CP *then* Service Quality Level Currently
[R9] *If Perception is* P *and* Hope T.P *then* Service Quality Level Currently
[R10] *If Perception is* P *and* Hope STP *then* Service Quality Level Low
[R11] *If Perception is* CP *and* Hope SP *then* Service Quality Level Tall
[R12] *If Perception is* CP *and* Hope P *then* Service Quality Level Tall
[R13] *If Perception is* CP *and* Hope CP *then* Service Quality Level Currently
[R14] *If Perception is* CP *and* Hope T.P *then* Service Quality Level Currently
[R15] *If Perception is* CP *and* Hope STP *then* Service Quality Level Low
[R16] *If Perception is* T.P *and* Hope SP *then* Service Quality Level Tall
[R17] *If Perception is* T.P *and* Hope P *then* Service Quality Level Tall
[R18] *If Perception is* T.P *and* Hope CP *then* Service Quality Level Currently
[R19] *If Perception is* T.P *and* Hope T.P *then* Service Quality Level Currently
[R20] *If Perception is* T.P *and* Hope STP *then* Service Quality Level Low
[R21] *If Perception is* STP *and* Hope SP *then* Service Quality Level Tall
[R22] *If Perception is* STP *and* Hope P *then* Service Quality Level Tall
[R23] *If Perception is* STP *and* Hope CP *then* Service Quality Level Currently
[R24] *If Perception is* STP *and* Hope T.P *then* Service Quality Level Currently
[R25] *If Perception is* STP *and* Hope STP *then* Service Quality Level Low

5. Determine the value of and method with a min value, Or method with a max value, Implication with a min value, Aggregation with a max value and defuzzification with a centroid type.
6. Measuring the level of service quality in the tangible dimension against the Fuzservqual GM5 display values from Simulink and Fuzservqual GM5 from the fuzzy logic designer.

4. Results

4.1 Descriptive Measurement of Perception-Expectations and Fuzzy Toolbox

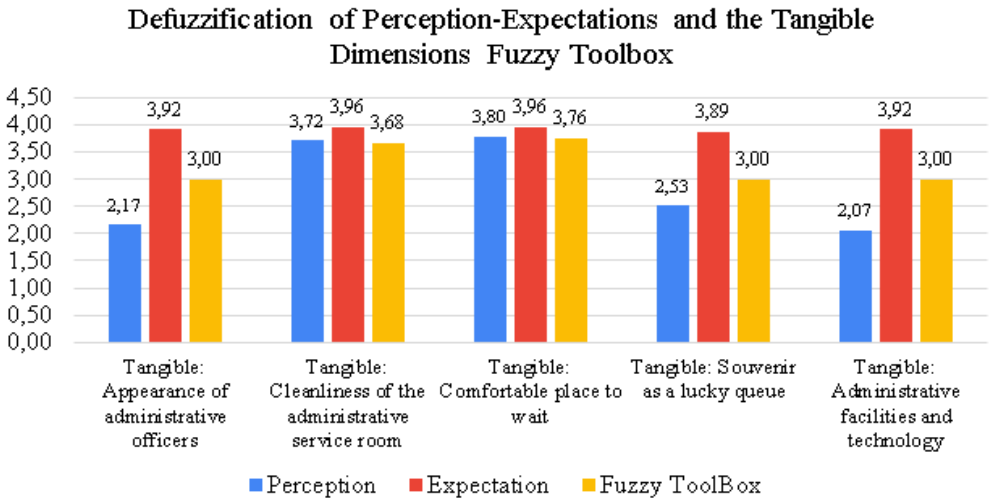

Fig. 1 *Defuzzification of perception-expectations and the tangible dimensions fuzzy toolbox*

Perception there are variations in perceived value between attributes. The attribute "Appearance of administrative officers" has the lowest perception value (2.17), indicating that customers have unfavorable perceptions of the appearance of officers. On the other hand, the attribute "Administrative facilities and technology" has the highest perception value (2.07), indicating that customers have a good perception of the facilities and technology provided. There are variations in expectations between attributes. The attribute "Administrative facilities and technology" again has the highest expectation value (3.92), indicating that customers have high expectations for facilities and technology. Meanwhile, the attribute "Souvenirs as a lucky queue" has the lowest expected value (3.89), indicating that souvenirs are not highly expected by customers.

4.2 Simulink Fuzservqual GM 5 Tangible Design

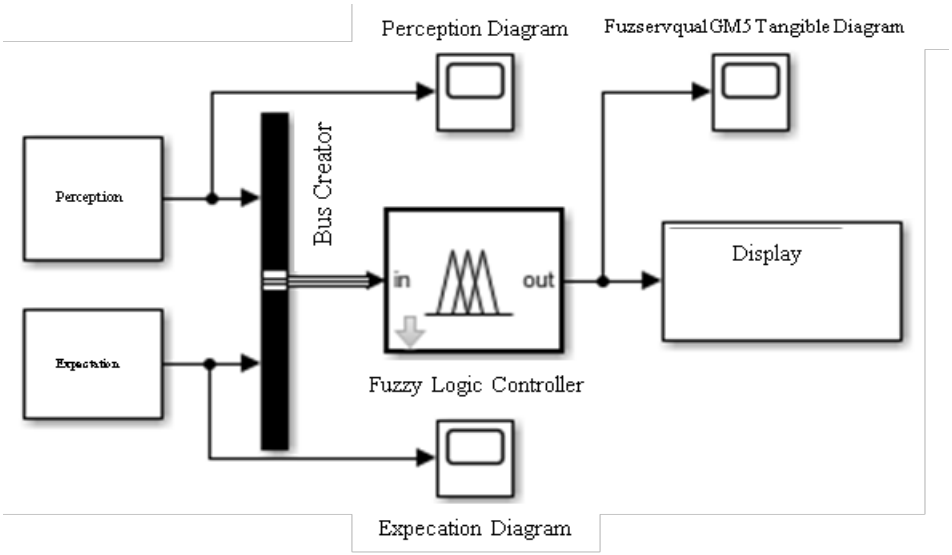

Fig. 2 *Simulink Fuzservqual GM 5 tangible design*

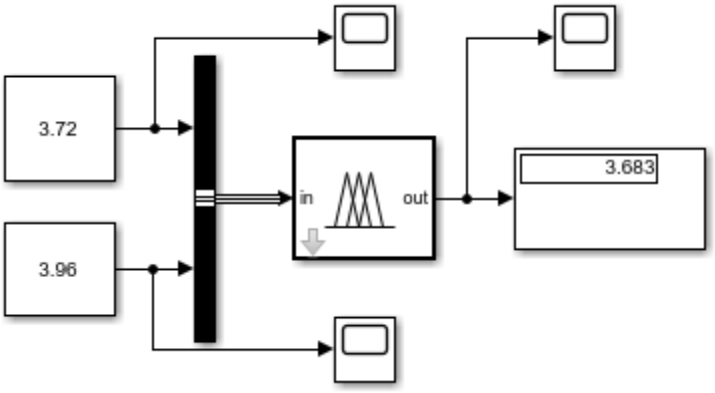

Fig. 3 *Fuzservqual tangible GM 5 tangible 3rd indicator results*

Fuzzy logic controller block diagram designed using Simulink helps understand and design fuzzy systems for various applications. Simulink's ready-to-use block libraries for fuzzification, inference, and defuzzification simplify design and simulation. The sample on Tangible GM 5 is the 3rd indicator, where the fuzzy system is used to evaluate service quality with a Fuzservqual result of 3.683, indicating good system performance.

4.3 Fuzzy Logic Designer GM 5 Tangible Design

Development of functional modeling of the membership function with an example of calculating the TGB1 attribute for respondent number 1. Respondent number 1 chose the TGB1 attribute by giving a scale value of 1. Function modeling, namely:

$$\mu STP_{[x]TGB1} = \begin{cases} 0 & ; x \geq b \\ \dfrac{(b-x)}{(b-a)} & ; a \leq x \leq b \\ 1 & ; x < a \end{cases} \quad (6)$$

Information:
a = the highest membership degree is 1 which is located at the value 1
x = assessment from the questionnaire on the TGB1 attribute for respondent number 1
b = highest domain value of the STP set

Based on the TGB1 attribute, it has a value of 1 which is in the expectation set with domains 1 – 2. The value 1 is in domains 1 – 2, so from the 3 formula function models$\mu STP_{[x]TGB1}$, what is used is. Thus, the resulting processed data is as follows:$\frac{(b-x)}{(b-a)} \quad ; a \leq x \leq b$

$$\mu STP_{[1]TGB1} = \frac{(2-1)}{(2-1)} \quad (7)$$

$$\mu STP_{[1]TGB1} = 1 \quad (8)$$

The fuzzy number set is used to measure perceptions and expectations with 5 categories: very dissatisfied, dissatisfied, quite satisfied, satisfied, and very satisfied. Each category has a domain and degree of membership. For example, the "satisfied" category has a domain of [3-5] and the highest membership degree at a value of 4.

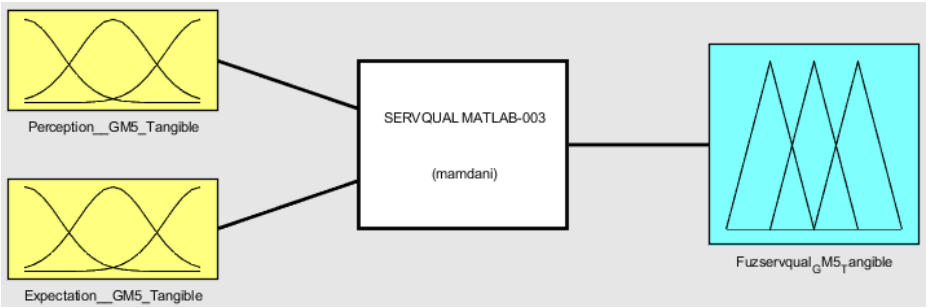

Fig. 4 *Mamdani Fuzzy Logic DesignDesigner GM 5 tangible*

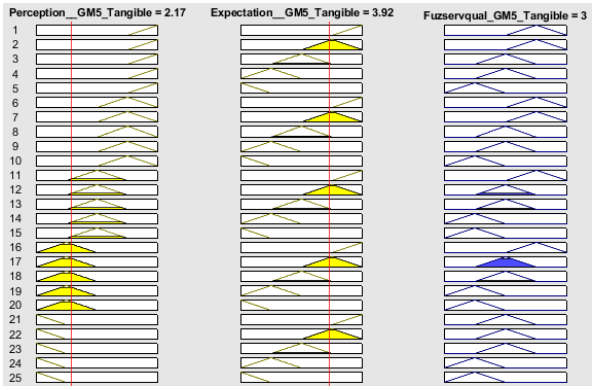

Fig 5 *Rules Fuzzy Logic Mamdani Designer GM 5 tangible*

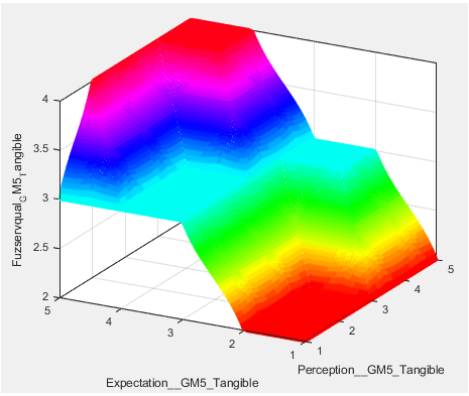

Fig 6 *Surface Fuzzy Logic Mamdani Designer GM 5 tangible*

4.4 Verify Fuzzy Simulink and Fuzzy Logic Mamdani Designer GM 5 Tangible

Table 4 *Fuzservqual Simulink and Fuzzy Logic Mamdani*

No.	Dimensions	Attribute Code	*Triangular Fuzzy Numbers* Perception			*Triangular Fuzzy Numbers* Expectations			Defuzzification		*Fuzservqual Simulink*	Fuzzy Logic Mamdani
			ap	BP	cp	Ah	bra	ch	Perception	Expectations		
1	*Tangibles*	TGB1	1.46	3.07	4.02	4.68	2.05	2.99	2.17	3.92	3,000	3.00
		TGB2	2.85	3.12	4.07	4.7	3.81	4.51	3.72	3.96	3,683	3.68
		TGB3	2.93	3.13	4.09	4.67	3.89	4.58	3.8	3.96	3,759	3.76
		TGB4	1.68	3.08	4.02	4.56	2.5	3.4	2.53	3.89	3,000	3.00
		TGB5	1.34	3.07	4.02	4.67	1.96	2.91	2.07	3.92	3,000	3.00

Measurement and analysis results using the Fuzservqual method which interacts with Simulink and Fuzzy Logic Mamdani, with a focus on the "Tangibles" dimension of the service, which consists of five attributes (TGB1 to TGB5). Each attribute has a specific code and a triangular fuzzy value for customer perception and expectations. The perceived and expected values are reflected by three numbers: BP (Base Point), cp (Central Point), and Ah (Apex Height). For example, for the TGB1 attribute, the perceived values are 1.46, 3.07, and 4.02, while the expected values are 4.68, 2.05, and 2.99. The defuzzification process changes fuzzy values into crisp values, with the defuzzification value for TGB1 being 3,000. Simulation using Simulink produces a value for each attribute, for example 3.00 for TGB1, while Mamdani fuzzy logic gives the same value. Other attributes, such as TGB2 to TGB5, also have corresponding perception, expectation, defuzzification, Fuzservqual Simulink, and Fuzzy Logic Mamdani values, which reflect how customers value and expect services in the Tangibles dimension.

Table 5 *Application testing verification*

No.	Dimensions	Attribute Code	*Fuzzy Simulink*	Fuzzy Logic Mamdani	Measurement	Application Testing Verification
1	*Tangibles*	TGB1	3,000	3.00	Quite satisfied	Succeed
		TGB2	3,683	3.68	Quite satisfied	Succeed
		TGB3	3,759	3.76	Quite satisfied	Succeed
		TGB4	3,000	3.00	Quite satisfied	Succeed
		TGB5	3,000	3.00	Quite satisfied	Succeed

Verification of application testing shows that in the tangible dimension, all attributes (TGB1 to TGB5) get quite satisfactory measurement values from customers, with Fuzzy Simulink results ranging from 3,000 to 3,759 and Fuzzy Logic Mamdani ranging from 3.00 to 3.76. All these measurements were successfully verified in application testing.

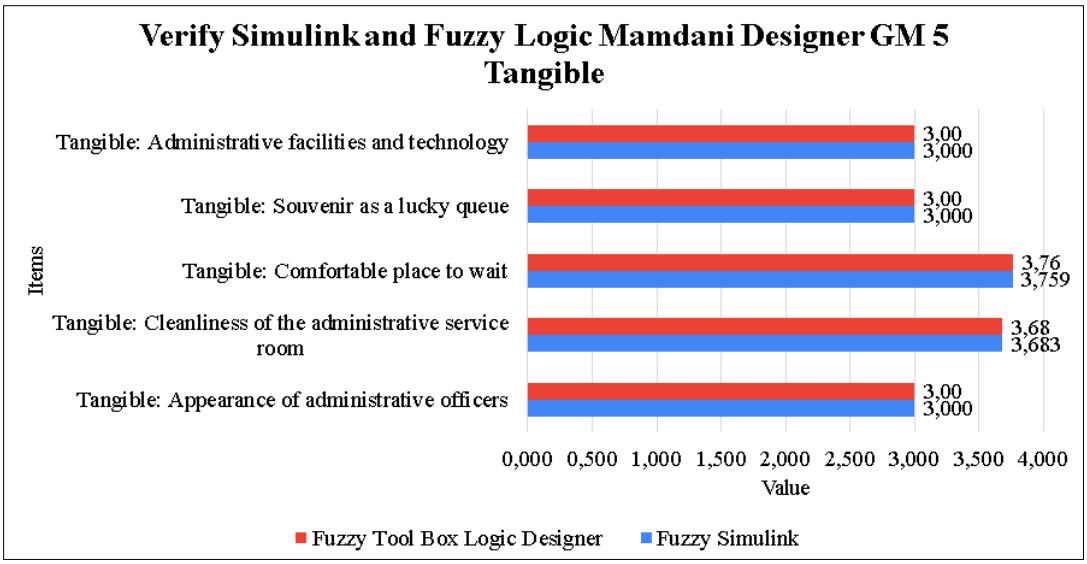

Fig. 7 *Verify Simulink and Fuzzy Logic Mamdani Designer GM 5 tangible*

5. Discussion

Analysis of service quality using Mamdani's Fuzzy Logic shows that overall customers are quite satisfied with the tangible aspects. The defuzzification results show a value of 3.00 - 3.76 for all tangible attributes, which is included in the "quite satisfied" category. Application testing shows that the centroid defuzzification method is successful in mapping customer perceptions and expectations into satisfaction categories. Suggestions for improving service quality include improving the physical and visual quality of service premises, cleanliness, completeness of facilities, and friendliness of staff. It is recommended to conduct similar analyzes for other dimensions and apply the analysis results to improve customer satisfaction.

Study examined impact of health IT on staff & services in aged care, with less focus on resident well-being[22]. This research builds a model to analyze heat in a single battery during discharge[23]. New framework improves life settlement pricing by handling limited and vague data with fuzzy numbers[24]. Simulating complex motor applications is difficult[25]. Indonesian study examines factors influencing public e-government service adoption using an enriched UTAUT model[26]. Study analyzes service quality gap between IT providers and consumers at ITS to improve service delivery[27]. Simulink model for single-channel optical transmission with noise consideration[28]. Study proposes new methods service quality measurements achieved in SERVQUAL and OWA-SERVQUAL; 5,563 was the quality measure using the IOWA-SERVPERF[29]. Analyzes methods for assessing insurance service quality using SERVQUAL in multiple countries[30]. Fuzzy logic model simulates coffee fermentation to remove mucilage, optimizing time for high-quality coffee[31]. Expanding MATLAB/Simulink's hardware simulation capabilities with user-built S-Function models[32]. Fixed VSG struggling in low inertia microgrids. This paper proposes adaptive VSG with fuzzy logic control for optimal frequency stability remarkable performance during disturbances and at varied RES penetration levels with 7.3% less frequency deviation and 46% less rate of change of frequency[33]. fuzzy control exceeds 0.45 under variable wind speeds. However, the wind energy utilization coefficient under hill climbing was varied significantly, and it was approximately 0.3 when

the wind speed changed significantly[34]. Service quality explains 68% of perceived service quality and 77% of e-learner satisfaction[35]. Cost model framework for complex aerospace assemblies in early design phase using MATLAB/SIMULINK[36]. geometry was chosen to perform the simulations. The input data for the dynamic model are represented by the user-imposed trajectory and the forming forces[37]. 6G networks explore integrating mobile ad-hoc networks for future IoT applications using fuzzy logic for improved QoS[11]. Rapid urbanization challenges city governments to manage services and meet citizen satisfaction[38]. Quality control in glass production is crucial for customer satisfaction and business success. This study prioritizes quality criteria for tempered glass using a fuzzy DEMATEL method, identifying "aspect measurement" as the most critical factor[39]. United Arab Empire study finds assessment methods, support services & teachers key to student satisfaction in public high schools[40]. the assessment of transportation quality to improve customer satisfaction and competitiveness[41]. Fuzzy logic improves Interior Permanent Magnet Synchronous (IPMSM) speed control reducing fluctuations under sudden load changes[42]. Stable elevator speed control system using fuzzy logic and simulation for improved comfort[43]. Proposed algorithm improves response speed by 12.72%, root-mean-square error by 31%, and total harmonic distortion by 30% compared to other fuzzy logic methods [44]. Fuzzy sliding mode controller proposed for AGC in deregulated power systems with distributed generators. Achieves better performance than traditional controllers under various conditions. Effectiveness is validated through simulations and real-time hardware[45]. Switched Reluctance Motors for electric vehicles suffer from torque ripple. This study proposes a fuzzy controller to reduce it in simulations[46]. Genetic Algorithm optimizes fuzzy controller for UAVs, reducing energy consumption and improving trajectory tracking[47]. New Simulink block offers robust differentiation for simulations, easily integrated and supports code generation[48]. Matlab/Simulink generates safety-compliant code for ARM processors, using a toolchain for model-based development[49]. High-speed train air brake system simulation helps diagnose faults for safe operation using a verified model[50]. Closed-loop DoH control system proposed for anesthesia using image-based signal acquisition and serial communication[51]. ANFIS for AVR control, achieving better performance than PID in transient response and adaptability (rise time of 1.1994s, settling time of 1.8818, overshoot of 1.3206, and steady-state error of 4.269e-04) were compared to other related works[52]. Fuzzy evaluation method is limited to about 74.6% indicating decent fitness of the sample size[53]. Fuzzy Logic improves MPPT performance in solar systems, boosting efficiency to 97% and reducing power fluctuations[54]. Study analyzes SERVQUAL use in private HEIs, identifying its current trends and future directions[55]. Builds reliable electric bicycle model in simulation and real-time achieving 25km range and 30km/h speed[56]. New method using fuzzy logic and deep learning to improve coverage quality in mobile crowd sensing by over 17%[57]. Pandemic stressed hospitals, leading to quality variations. Study finds caring, accuracy, skills and timeliness most crucial for good service[58]. Fuzzy inference system indicated very high, high, and medium impacts of the risks on the overall productivity of the PPP projects in terms of time, cost, and quality, respectively[59]. Model of the proposed ZVS based IASL converter with FLC is implemented and the results are verified with simulation results obtained from MATLAB Simulink[60]. Superconducting flux pump model simulates real system's behavior including thermal effects for accurate performance prediction[61]. Fuzzy PSS controller to regulate frequency in a microgrid with EVs under uncertainty[62]. Study finds link between bank tech quality and customer satisfaction, except for responsiveness and empathy[63]. Fuzzy C-means clustering, improved using a simulated annealing genetic algorithm, was adopted to partition user perception into 2 to 10 clusters[64]. Parallel NIDS with 3 queues tripled Snort's processing speed (100% packets analyzed in 103s) leveraging QoS[65]. Evaluating tool effectiveness for service quality at the company level, highlighting improvement areas in utilities' performance [66]. Improved water access but quality suffers (38.1% max) due to limited production and unreliable electricity[67]. The proposed model, evaluated using 15,511 TripAdvisor reviews of luxury hotels in London, effectively captures and summarizes customer satisfaction, enabling hotel managers to identify improvement areas and uncover business opportunities [68]. New fuzzy control method (NAFC) improves car stability and reduces rollover risk in high-speed maneuvers. The numbers 0.97 and 0.91 represent the performance metrics or effectiveness of the PID controller in these scenarios. Higher values indicate better performance or closer alignment with desired outcomes [69].

While numerous studies explore using fuzzy logic and Simulink for diverse applications, their integration in service quality measurement remains largely unaddressed. This research highlights the potential of such an integration based on the finding that Simulink and Fuzzy Logic Mamdani produce very similar Fuzservqual results. Combining these tools could lead to a robust service quality measurement system for the tangible dimension.

Simulink and Fuzzy Logic Mamdani produce almost the same results when it comes to Fuzservqual. This can be seen from the Fuzservqual values which are very similar for all attribute codes, with very small differences. Although there are differences, they are likely not significant in the context of the application. This is because small differences in Fuzservqual values may not have a significant impact on system performance. Simulink and Fuzzy Logic can be integrated to design a robust service quality measurement system in the tangible dimension. Simulink allows researchers to determine the level of detail of Fuzservqual GM5 measurements, system simulation and optimization, and system visualization. Fuzzy Logic provides a framework for building embryos and visual

prototypes of systems, enabling flexibility and customization, as well as data analysis and interpretation. This integration offers an accurate, efficient and effective measurement system, helping to improve overall service quality. Optimizing resources and increasing customer satisfaction are top priorities in the modern service world. Design studies using Simulink and Fuzzy Logic show that although tangible aspects of the service have satisfied customers, there is a need for further improvement. The integration of these two technologies enables detailed system modeling and data maintenance and variability, which helps identify weak points and provide appropriate improvement recommendations. The system also enables resource optimization, system simulation and visualization, as well as quality improvement and service customization. With higher accuracy and measurement, as well as time and cost savings, these systems facilitate more collaboration and development, adapt to different types of services and contexts, and meet specific organizational needs, so that overall service quality can be improved.

6. Conclusion

This research develops a more sophisticated, accurate and efficient service quality measurement system for the tangible dimension by integrating Simulink and Fuzzy Logic. The research results show that customers are quite satisfied with the tangible aspects of the service. The integration of Simulink and Fuzzy Logic allows researchers to determine the level of measurement detail, perform system simulation and optimization, visualize the system, and increase system flexibility and customization. This system offers accurate, efficient and effective measurements, which can help improve overall service quality.

Future research could focus on other dimensions of service quality and apply the analysis results to increase customer satisfaction. The integration of Simulink and Fuzzy Logic has great potential to improve service quality in various sectors. Optimizing resources and increasing customer satisfaction are top priorities. Integrating Simulink and Fuzzy Logic enables detailed system modeling, resource optimization, and accurate measurements, leading to improved service quality, customization, and cost savings while meeting specific organizational needs and facilitating collaboration.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

Study conception and design: *Alfian Pradana, Johan;* ***data collection:*** *Nur Astari, Alifah and Alfian Pradana, Johan;* ***analysis and interpretation of results:*** *Nur Astari, Alifah and Alfian Pradana, Johan;* ***draft manuscript preparation:*** *Nur Astari, Alifah. All authors reviewed the results and approved the final version of the manuscript.*

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