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Teacher discipline assessment with Mamdani Fuzzy Logic decision support system on attendance data at Phatnawitya School Yala

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ABSTRACT

Teacher discipline is a crucial factor in maintaining the quality of the learning process in schools; however, discipline assessment is often conducted subjectively and relies on rigid threshold values. This study aims to develop a decision support system based on Mamdani Fuzzy Logic to evaluate teacher discipline using attendance data. The research method includes fuzzification, Mamdani fuzzy inference, and defuzzification using the centroid method, with two input variables attendance and absence without permission (alpha) and one output variable in the form of a discipline score. The results indicate that teachers with attendance ≥90% and alpha ≤3 days are classified as "Very Good", those with attendance between 80-89% fall into the "Good" to "Fair" categories, while attendance below 75% or alpha above 12 days is categorized as "Poor". The fuzzy system produces consistent, stable, and flexible assessments through gradual value transitions. In conclusion, Mamdani Fuzzy Logic is effective as a more objective and realistic tool for evaluating teacher discipline compared to conventional threshold-based methods.

INTRODUCTION

Teacher discipline is a key element in maintaining the quality of learning and the effectiveness of educational management in schools. Teachers with high levels of discipline tend to demonstrate consistency in attendance, punctuality, and the fulfillment of professional responsibilities, which directly supports the creation of a conducive and sustainable learning environment. With the development of information technology, various studies have shown that the use of intelligent systems and fuzzy-based decision support systems can improve the objectivity and consistency of performance evaluations in the field of education (Afanasyev et al., 2018; Chkiwa et al., 2023; Ilahi et al., 2018; Wang & Zhou, 2025).

Phatnawitya School Yala is a private Islamic school that provides education from kindergarten to high school with a relatively large number of teachers and a well-documented administrative system. In this context, teacher discipline is a strategic aspect that determines the continuity of the learning process and the stability of school management (Masum et al., 2018). However, in practice, teacher discipline assessments are often still carried out manually and subjectively, which has the potential to cause inconsistencies, especially when there are a large number of teachers and attendance data has not been processed systematically. In fact, teacher attendance data is a source of quantitative information that can be used objectively to evaluate the discipline and performance of teaching staff (Basloom et al., 2020; Sitompul et al., 2024).

Decision Support Systems (DSS) have been widely applied in the fields of education and human resource management to assist in the process of structured and transparent performance evaluation. The integration of DSS enables the systematic processing of attendance data and other performance indicators, resulting in more consistent and accountable assessment recommendations (Dam et al., 2021; Fauziah & Arifin, 2023). However, the gradual and not always clear-cut nature of attendance data means that a deterministic threshold-based approach is less able to represent the actual state of discipline realistically.

To overcome this problem, fuzzy logic is widely used in decision support systems because of its ability to represent uncertainty and linguistic assessments flexibly. The Mamdani Fuzzy method has

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the advantage of an intuitive IF–THEN rule structure that is easy for decision makers to understand, making it effective for application in performance and human behavior evaluation, including in the context of education (Han & Wan, 2025; Palaniappan & Suganthi, 2023; Sann, Z., & Soe, 2018).

Previous studies, such as Afanasyev et al. (2018) and Chkiwa et al. (2023), developed fuzzy-based intelligent systems in the field of education, but did not specifically assess teacher discipline based on attendance data. Research by Sann, Z. & Soe (2018) and Popescu & Pistol (2021) applied fuzzy logic in teacher performance evaluation, but did not integrate attendance data as a key indicator of discipline. Meanwhile, Basloom et al. (2020) and Sitompul et al. (2024) utilized fuzzy logic in attendance systems, but their studies focused more on attendance efficiency than modeling teacher discipline as linguistic output in a decision support system framework.

Based on these gaps, previous studies generally still separate decision support systems, the application of fuzzy logic, and the use of teacher attendance data as an indicator of discipline. There have not been many studies that specifically integrate Decision Support Systems with the Mamdani Fuzzy Logic method to assess teacher discipline based on attendance data with outputs in the form of linguistic categories that are easy for school management to interpret (Qian et al., 2024; Yang & Arshad Malik, 2025).

The novelty of this research lies in the development of a Mamdani Fuzzy Logic-based decision support system that specifically models teacher discipline using attendance data (attendance and alpha) as input variables and produces outputs in the form of discipline scores and linguistic categories. Based on this novelty, the purpose of this study is to develop a decision support system using the Mamdani Fuzzy Logic method to assess the level of teacher discipline based on attendance data at Phatnawitya School Yala in order to support objective and transparent managerial decision making.

RESEARCH METHODS

This research is applied research with a descriptive quantitative approach that aims to develop a Decision Support System (DSS) to assess the level of teacher discipline using the Mamdani Fuzzy Logic method. The fuzzy approach was chosen because it is capable of representing uncertainty in attendance data and producing outputs in the form of linguistic assessments that are gradual, flexible, and easy to interpret in the context of educational performance evaluation (Afanasyev et al., 2018; Ardil, 2017; Ilahi et al., 2018)..

The research was conducted at Phatnawitya School Yala, Southern Thailand, covering attendance data for the 2024 school year (January–December). The research population included all 207 active teachers, while data from 10 teachers were randomly selected as samples for developing and testing the DSS model. The attendance data used were compiled simulatively based on the MISSTD application template to represent real attendance patterns while maintaining the privacy and confidentiality of teacher data. The use of simulated data in this study was intended to focus testing on the conceptual validity and logical consistency of fuzzy system inference, rather than to perform statistical generalization. This approach is commonly used in model-oriented research, particularly in the early stages of designing and evaluating fuzzy-based decision support systems (Basloom et al., 2020; Iqbal, 2018; Sitompul et al., 2024).

The research flow begins with processing attendance data to obtain attendance percentages and alpha percentages as input variables, while the output variable is the teacher's discipline score in the range of 0–100. Next, the data is processed through the stages of fuzzification, inference based on Mamdani Fuzzy Logic rules, and defuzzification to produce the final discipline score. The general flow of the assessment system is shown in Figure 1.

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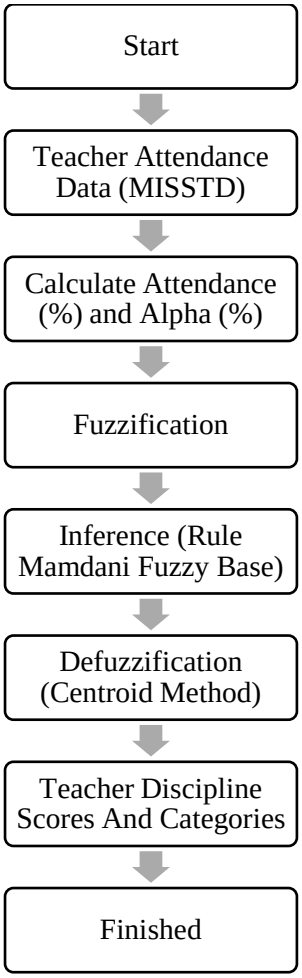

Figure 1. Research stage flowchart

In the fuzzification stage, numerical input values are mapped into fuzzy sets using triangular membership functions. The input variables consist of attendance and alpha, while the output variable is teacher discipline, represented in the linguistic categories "Poor," "Fair," "Good," and "Very Good." The determination of membership function parameters and linguistic categories is based on the conceptual rationalization of teacher discipline assessment and references from the literature on fuzzy-based performance evaluation.

The inference stage was carried out using nine fuzzy rules constructed from a combination of attendance levels and alpha. The inference rules were designed in the form of IF–THEN rules that reflect the conceptual relationship between the input variables and the output of discipline. In the implication stage, the MIN operator was used, and in the aggregation stage, the MAX operator was used, in accordance with the characteristics of the Mamdani Fuzzy method, which emphasizes interpretability and transparency of reasoning (Popescu & Pistol, 2021; Sann, Z., & Soe, 2018).

Table 1. Mamdani Fuzzy Inference Rules

Attendance	Alpha	Discipline
Height	Low	Very Good
Height	Currently	Good
Height	Height	Enough
Currently	Low	Good
Currently	Currently	Enough
Currently	Height	Less
Low	Low	Enough
Low	Currently	Less
Low	Height	Less

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The defuzzification stage is carried out to convert fuzzy output into crisp values in the form of final teacher discipline scores using the centroid method, which is formulated as follows:

$$z^* = \frac{\int z\, \mu(z)\, dz}{\int \mu(z)\, dz}$$

Where z^* is the discipline score value, z represents the output variable in the range of 0–100, and $\mu(z)$ is the membership value of the aggregation of all rules. The centroid method was chosen because it can produce representative values and has a high level of interpretability for decision makers. This study did not use statistical reliability tests or expert validation because the developed system was not based on questionnaires or subjective assessments, but rather on deterministic and rule-based fuzzy logic inference. The consistency of the system was evaluated by observing the stability of the output against small variations in the input values. In addition, this study has not yet made comparisons with other fuzzy methods such as Sugeno or Tsukamoto. Therefore, the results of this study focus on the conceptual and systemic evaluation of the Mamdani Fuzzy model's performance as an initial stage of development, with opportunities for empirical testing, expert validation, and comparative studies of fuzzy methods in future research.

RESULTS AND DISCUSSION

This study produced a Mamdani Fuzzy Logic-based Decision Support System (DSS) to assess teacher discipline based on school attendance data. The Mamdani Fuzzy method was chosen for its ability to convert numerical data, such as attendance and unexplained absence (alpha) percentages, into gradual and flexible decisions. This approach is considered more representative in modeling human behavior, which is fraught with uncertainty and ambiguity, compared to deterministic methods based on fixed thresholds, especially in the context of evaluating education and teacher performance (Afanasyev et al., 2018; Ilahi et al., 2018; Palaniappan & Suganthi, 2023).

The fuzzy model was designed with two input variables, namely Attendance (%) and Alpha (%), and one output variable in the form of Discipline (0–100). Each variable is modeled using a triangular membership function. The triangular function was chosen based on its computational simplicity, ease of interpretation, and ability to represent gradual changes in value. This approach is in line with various studies that implement triangular membership functions in fuzzy-based human behavior and performance evaluation systems (Kouatli, 2018; Masum et al., 2018; Palaniappan & Suganthi, 2023; Yang & Arshad Malik, 2025).

To support openness and ease of replication, the testing and visualization of membership functions were performed using an automated Excel template developed with the help of Python. This approach allows for the visualization of fuzzy curves without relying on specialized software such as MATLAB, thereby increasing the accessibility and transparency of the system for schools. A similar approach is also recommended in the development of fuzzy-based attendance and evaluation systems so that they can be easily adopted by educational institutions with limited technological resources (Basloom et al., 2020; Iqbal, 2018).

Case Study: Teacher YY

As the main case study, the system was tested using data from Teacher YY with an attendance rate of 91% and an alpha value (unexcused absences) of 2%. The initial stage in a fuzzy system is fuzzification, which is the process of converting numerical values into membership degrees (μ) in each fuzzy set. The fuzzification results show that the attendance value has the highest membership degree in the High ($\mu = 0{,}7333$) category, while the alpha value has the highest membership degree in the Low ($\mu = 0{,}3333$) category. Based on these conditions, the active fuzzy rule is: IF attendance is high AND alpha is low THEN discipline is very good. In the Mamdani inference stage, the minimum operator is used as a representation of the AND logic operator to determine the rule activation strength (firing strength), resulting in the following values:

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$$\propto = \min(0{,}7333, 0{,}3333) = 0{,}3333$$

The use of the MIN operator in Mamdani inference is a common approach because it reflects conservative linguistic reasoning and facilitates tracing the contribution of each rule to the system output (Han & Wan, 2025; Palaniappan & Suganthi, 2023; Popescu & Pistol, 2021; Sann, Z., & Soe, 2018, 2018).

The firing strength value of $\propto = 0{,}3333$ is then used in the implication stage by clipping the "Very Good" output membership function with the trimf parameter (75, 90, 100). The clipping results in intersection points on the left and right sides of the triangle, namely $z_L = 80.00$ and $z_R = 96{,}67$.

The final stage is defuzzification, which aims to convert fuzzy results into crisp values. The method used is the centroid method, which is formulated as follows:

$$z^* = \frac{\int_{75}^{100} z\, \mu_{aggregated}(z)\, dz}{\int_{75}^{100} \mu_{aggregated}(z)\, dz}$$

Based on the calculation of the area and moment on the left side, the cut section, and the right side of the output curve, the total area $D \approx 6{,}944$ and moment $N \approx 610{,}29$ values are obtained, so that the defuzzification value is:

$$z^* = \frac{N}{D} \approx 87{,}89$$

This value falls within the domain of the membership function of the "Very Good" category with parameters (75, 90, 100) and has the highest degree of membership in that category. Thus, Teacher YY is classified into the "Very Good" discipline category objectively based on fuzzy calculations, not subjective assessments.

Figure 2 shows that the attendance value of 91% has a dominant membership degree in the High category ($\mu = 0{,}7333$).

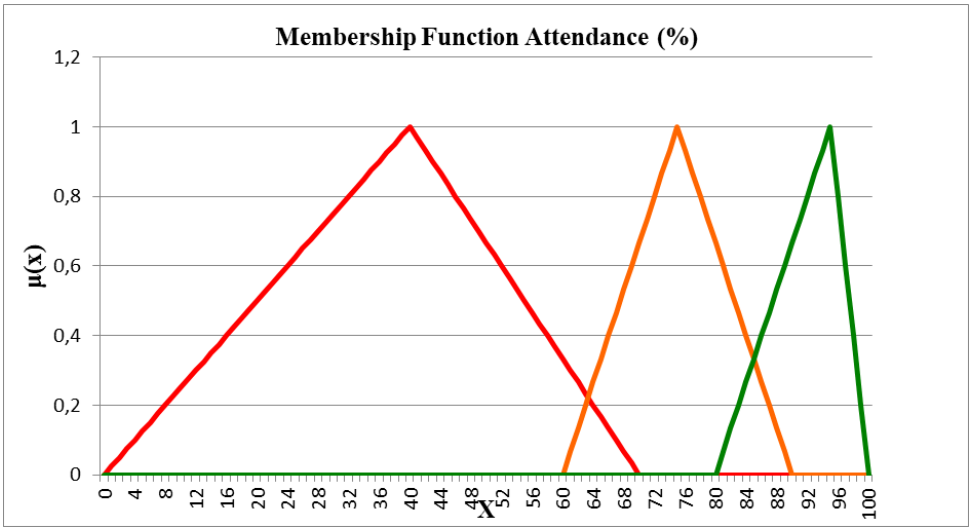

Figure 2. Curve of Teacher YY Attendance Membership Function (%)

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Figure 3 shows that the alpha value of 2% falls into the Low category ($\mu = 0{,}3333$).

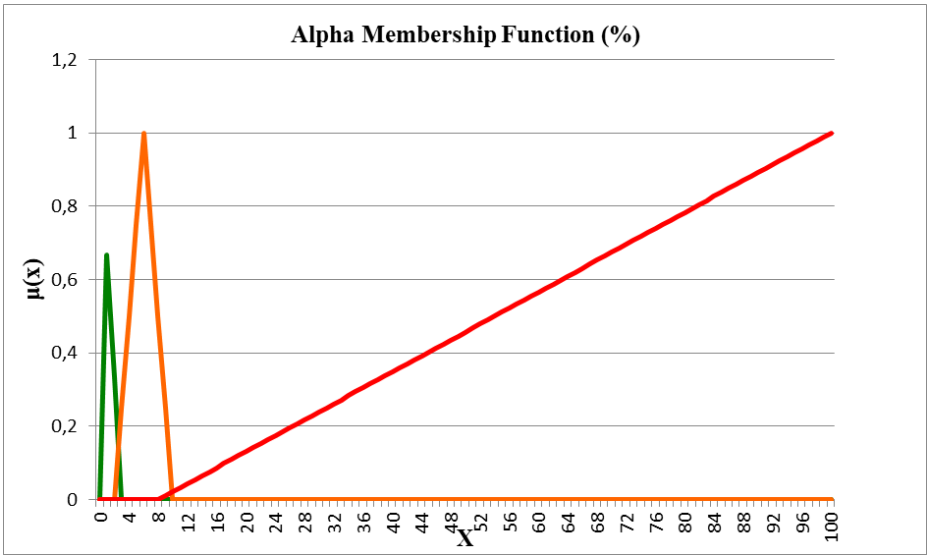

Figure 3. Alpha Membership Function Curve for YY Teachers (%)

Figure 4 shows the dominant fuzzy output results in the "Very Good" category after undergoing the inference and defuzzification processes.

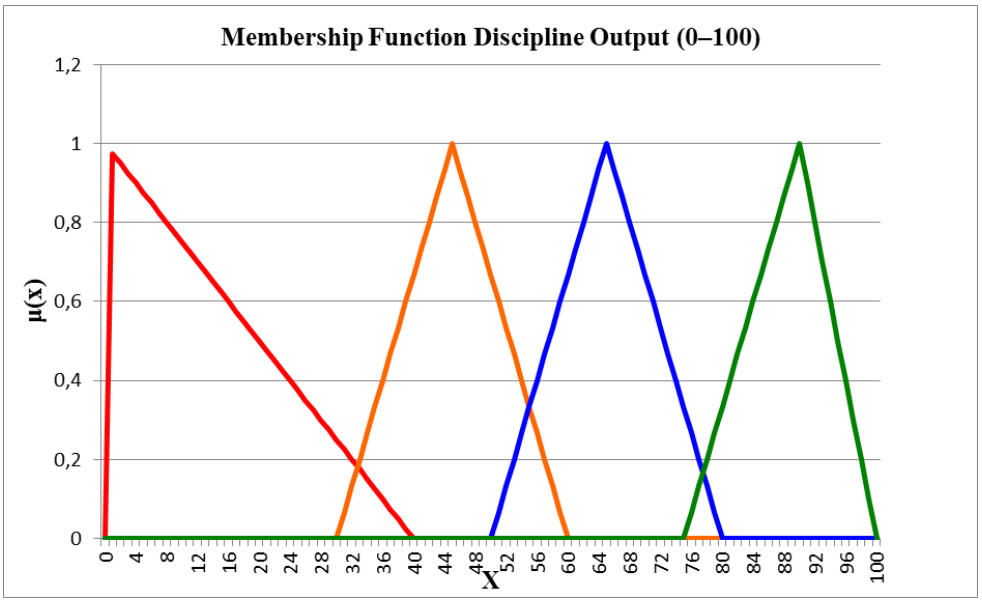

Figure 4. Membership Function Curve of Teacher Discipline Output YY (0–100)

The membership function curves shown in Figures 2 to 4 play an important role in explaining the fuzzy inference process visually and interpretively. The visualization of the curve allows readers to understand how numerical values are mapped into linguistic categories and how system decisions are generated gradually, rather than discretely. This visual approach is commonly used in fuzzy-based decision support systems because it improves the readability and transparency of the evaluation process, especially in the context of education and performance appraisal (Afanasyev et al., 2018; Ilahi et al., 2018; Palaniappan & Suganthi, 2023).

Figure 2 shows the membership function curve of the Attendance (%) variable. In the case of Teacher YY, the attendance value of 91% is in the transition region between the Medium and High categories, with the highest membership degree in the High category (μ = 0.7333). This condition shows that even though the attendance value is relatively high, the fuzzy system does not immediately classify it absolutely, but instead considers the degree of proximity to other categories gradually. This

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mechanism is in line with the concept of gradual evaluation in fuzzy logic, which avoids the use of rigid value limits in human performance assessments (Kouatli, 2018; Sann, Z., & Soe, 2018).

Furthermore, Figure 3 displays the membership function curve of the Alpha (%) variable. An alpha value of 2% has the highest membership degree in the Low category (μ = 0.3333). This curve shows that the system not only considers the absolute number of absences but also their intensity in the specified fuzzy domain. This type of modeling is commonly used in fuzzy-based evaluation systems because it can represent uncertainty and behavioral variation more realistically than deterministic approaches (Basloom et al., 2020; Iqbal, 2018; Sitompul et al., 2024).

Figure 4 shows the membership function curve of the discipline output after going through the inference and defuzzification processes. The aggregation of the curves shows the dominance of the Very Good category, which results from the activation of fuzzy rules with a combination of high attendance and low alpha. The clipped output curve reflects the contribution of active rules with a certain firing strength, so that the resulting decision is proportional and can be traced back to the fuzzy rules used. This characteristic is a major advantage of the Fuzzy Mamdani method in supporting decision interpretability (Palaniappan & Suganthi, 2023; Popescu & Pistol, 2021).

Overall Teacher Assessment Results:

Table 2. Results of Teacher Discipline Assessment Using Mamdani Fuzzy Logic

Teacher ID	Initials	Attendance (%)	Alpha (%)	Discipline Score (z^*)	Category
psy178	YY	91	2	87,89	Excellent
psy081	SW	89	4	82,45	Good
psy138	MK	86	5	79,77	Good
psy179	FT	83	8	74,60	Enough
psy166	AW	80	10	70,22	Enough
psy072	NS	95	0	92,31	Excellent
psy073	AM	88	3	84,55	Good
psy096	AN	76	12	68,11	Enough
psy094	MH	72	15	63,74	Less
psy020	CW	78	9	71,02	Enough

Based on the fuzzy calculation results in Table 2, teachers with attendance $\geq 90\%$ and alpha ≤ 3 levels tend to be classified into the "Very Good" category, while teachers with attendance levels 80-89% are categorized as 'Good' to "Fair," depending on the alpha value. This pattern shows that the fuzzy system is capable of representing the gradual relationship between attendance and teacher discipline proportionally.

The determination of the discipline category in this study was not done directly based on the final score, but based on the position of the defuzzification result value against the membership function domain of the output variable. The discipline output variable was designed in four linguistic categories, namely Poor, Fair, Good, and Very Good, each of which was represented using a triangular membership function.

For example, Teacher YY's discipline score of 87.89 is the result of centroid defuzzification and falls within the membership function domain of the Very Good category with parameters (75, 90, 100). This value has the highest membership degree in the "Very Good" category compared to other categories. Therefore, classification is based on the principle of maximum membership, so that category determination is objective and entirely based on fuzzy calculations (Kouatli, 2018; Palaniappan & Suganthi, 2023).

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Analysis of Results

The results show a positive relationship between attendance and teacher discipline. The higher the attendance percentage and the lower the alpha (unexcused absences), the higher the fuzzy-based discipline score. These findings indicate that attendance data can be used as an objective quantitative indicator in assessing teacher discipline (Afanasyev et al., 2018; Palaniappan & Suganthi, 2023; Sann, Z., & Soe, 2018).

Based on the results of calculations using the Mamdani Fuzzy method, teachers with an attendance rate of ≥90% and an alpha value of ≤3 days tend to have an Excellent level of discipline. Meanwhile, teachers with attendance of 80-89% and an alpha value between 4-10 days are generally in the Good to Fair category. This pattern confirms the conceptual relationship between attendance and discipline, where an increase in attendance has a direct impact on the discipline score generated by the fuzzy system (Kouatli, 2018; Palaniappan & Suganthi, 2023).

Unlike conventional approaches that use fixed thresholds, the Mamdani Fuzzy system allows for a smooth transition of values between discipline categories. Small changes in attendance or alpha values do not directly result in extreme category changes, but rather remain within a proportional membership range. Fuzzy systems are able to handle uncertainty through flexible linguistic representations without relying on rigid value limits (Ilahi et al., 2018; Kouatli, 2018). This approach is in line with human thinking, which bases decision-making on degrees of certainty rather than absolute numerical values. This concept is known as gradual classification, which is one of the main advantages of fuzzy logic in assessing human behavior (Palaniappan & Suganthi, 2023; Yang & Arshad Malik, 2025).

Teachers with an attendance rate below 75% or an alpha value above 12 days are classified into the Poor category, indicating that the fuzzy system is capable of detecting a gradual decline in discipline. This proves that Mamdani Fuzzy Logic can map the non-linear relationship between attendance and discipline more accurately than conventional methods based on fixed thresholds (Chkiwa et al., 2023; Sann, Z., & Soe, 2018).

The results of this study are in line with previous findings which state that fuzzy-based decision support systems produce more adaptive and realistic performance evaluations than deterministic methods that rely solely on single numerical values. The addition of linguistic interpretation in fuzzy systems also improves the readability of results and ease of understanding for decision makers in educational environments (Afanasyev et al., 2018; Han & Wan, 2025; Palaniappan & Suganthi, 2023).

It should be emphasized that this study does not aim to measure the strength of the relationship between variables statistically inferentially. The main focus is on the conceptual and systemic evaluation of disciplinary behavior through fuzzy modeling. Therefore, the analysis presented is interpretative based on fuzzy inference, in accordance with the characteristics of the Mamdani method, which emphasizes linguistic reasoning over numerical significance (Kouatli, 2018; Palaniappan & Suganthi, 2023).

To test the stability of the system, a simple sensitivity test was conducted by increasing and decreasing the attendance and alpha values by ± 5% in several teacher samples. The test results showed that small changes in input values did not cause shifts in discipline categories, but only affected discipline scores by around ± 3 points. These findings indicate that the system has adequate internal consistency and is not overly sensitive to small fluctuations that commonly occur in school attendance data (Basloom et al., 2020; Sitompul et al., 2024).

Overall, the analysis results show that the Mamdani Fuzzy method is capable of providing a more realistic, flexible, and contextual assessment of teacher discipline compared to traditional approaches based on fixed thresholds. The model successfully represents the gradual cause-and-effect relationship between attendance, alpha, and discipline level, and produces assessment categories that are intuitive and easy for schools to understand (Palaniappan & Suganthi, 2023; Sann, Z., & Soe, 2018; Yang & Arshad Malik, 2025).

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Although the developed system shows consistent and stable results, this study has several limitations. The data used is still structured simulation, so the results cannot be empirically generalized to a wider population of teachers. In addition, this study has not compared the performance of the Mamdani method with other fuzzy methods such as Sugeno or Tsukamoto. These limitations open up opportunities for further research to conduct empirical validation using real data and to compare various fuzzy methods in the context of teacher discipline evaluation (Rezeki & Putra, 2021; Yunan & Alib, 2020).

CONCLUSION

This study successfully developed a Mamdani Fuzzy Logic-based Decision Support System to assess teacher discipline levels based on attendance data at Phatnawitya School Yala, with attendance and alpha as inputs and discipline scores as outputs. The test results show that the system is capable of producing consistent, stable, and easily interpretable assessments, with gradual value transition characteristics that are more flexible than conventional approaches based on fixed thresholds. These findings indicate that Mamdani Fuzzy Logic is suitable for use as a data-based decision-making tool in evaluating teacher discipline in educational settings. However, this study is still limited to the use of two main variables and simulated data, so further research is recommended to use empirical data, add other relevant discipline variables, conduct expert validation, and compare the Mamdani Fuzzy method with other fuzzy methods such as Sugeno or Tsukamoto. In addition, the development of the system towards web-based or mobile implementation is expected to increase the practicality and effectiveness of the system's utilization by schools.

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