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A COMPARISON ON STUDENTS' PERFORMANCE IN MATHEMATICS SUBJECT USING FUZZY LOGIC THEORY

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Abstract:

The education system in Malaysia employs classical method in evaluation students' progress performances during their foundation level. The result was obtained by adding all the assessments scored and was graded based on grade A, A-, B+, B, …, and F. Somehow, non-classical methods may be applied such as fuzzy logic, where it can be applied to many forms of decision making. This paper proposed evaluation on students' performances by using fuzzy logic approach. The assessment score obtained based on their assignment, midterm examination and final term examination of 26 Agriscience students, in Preparatory Centre for Science and Technology (PPST), University Malaysia Sabah, UMS was carried out with fuzzy logic. Their results are calculated based on classical method and fuzzy logic approach, which is then compared and analysed. The comparison shows variation between classical and fuzzy logic approach in terms of their overall results.

Keywords:

Fuzzy Logic Theory, Fuzzy Rules, Fuzzy Number, Triangular Membership Function

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Introduction

The improvement of students' learning performance is one of the ultimate objectives in our educational systems. A highly relative fair evaluation system is needed to ensure that all students received fair evaluation in their studies. The measurement of educational performances is usually expressed numerically, which is based on their grade in examinations results. In instances, evaluation students' performance is obtained by a few methods. The most popular one is by using the classical methods, whereby the grade of students is obtained by the summation of the total marks obtained according to the assessments given to students as well as their midterm and final term examinations. However, evaluation in students' assessment such as in their assignment assessment are based on rigid scoring criteria which sometimes may not be suitable or appropriate discussed by Saleh and Kim (2009).

Fuzzy evaluation method in fuzzy logic and reasoning has been approved to be beneficial to serve the student academic performance evaluation as mentioned in Biswas (1995), Law (1996), Chang and Sun (1993). They proved that fuzzy logic approach has some advantages over the classical method. Semerci (2004) proposed an experimental method in fuzzy logic and trying to explain the influence of fuzzy logic theory on student's achievement. Meanwhile, Gokmen et al. (2010) shows various in student's evaluation performance by using classical method and fuzzy logic approaches. They found that evaluation by using fuzzy logic approach is more flexible and provides more options, especially to teachers.

Saleh and Kim (2009) introduced method on student's evaluation performances by using fuzzy logic. They proposed method in fuzzifications, defuzzification according to the level of difficulty, importance, and complexity of questions. This method proved to be easy, and the result is fair and accurate. Chrysafiadi and Virvou (2012) evaluate the effectiveness and accuracy of the student model of a web-based educational environments for teaching computer programming. This also imply the updating of the student model and the decision-making about the instruction model that the system should follow for each individual learner, are based on the fuzzy logic technique that we incorporate into the student model.

Barlybayev et al. (2016) propose a fuzzy model of performance evaluation of students through the establishment of performance. In their research, they managed to prove the advantages of using fuzzy logic in the evaluation of students' knowledge is better than classical method. Wen and Liu (2021) proposed a new fuzzy inference mechanism to calculate student's ranking order without dependence of the answer times. It enriches the present evaluation approach of student's performances, and it can be utilized to analyse the direct relationship of the student's scores and the corresponding questions.

In this paper, fuzzy logic approach is applied to evaluate students' performance in terms of scoring and grading in Mathematics paper. In the process of applying fuzzy logic, three main input variables used, which is their score in assignments, Midterm examination and Final term examinations. 29 fuzzy rules are designed to implement the fuzzy logic theory. The rest of the paper is organized as follow. We give brief overview of fuzzy logic and some application in the previous study. Section 3 explain about the objectives and the limitation of the study. The next section is the methodology on proposed research design. The results and analysis of the data are discussed in Section 5. Conclusions are drawn in Section 6.

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Fuzzy Logic

Fuzzy logic set was initially introduced by Zadeh (1965) emerged with the article of fuzzy sets. It is a mathematical way to express linguistics variables, vagueness, and uncertainty. According to his explanation in fuzzy logic concept, all factor or criteria can be classified without certain limit.

Fuzzy logic usually uses variables such as, "Low", "High", "Normal" to represent "Yes/No" or "True/False" variables. In fuzzy set, the data are represented by membership function. In other words, the data is depending on their belongingness to a number between 0 and 1. A higher membership function or higher value of belongingness (which is up to 1), shows stronger degree of membership to set A as mentioned by Timothy (2004) and Zimmermann (2001).

Sen and Cenkci (2009) mentioned that fuzzy sets can be characterized by numerous membership functions. In this study, we employ triangular membership fuzzy number of $\mu = (\gamma, \alpha, \beta)$ for $\alpha > 0, \beta > 0$ with their membership functions as shown in Equation 1 (Zadeh (1965)):

$$\mu_{\mu}(x) = \begin{cases} \dfrac{x-\gamma}{\alpha} + 1, & \gamma - \alpha \le x \le \gamma \\ \dfrac{\gamma - x}{\beta} + 1, & \gamma \le x \le \gamma + \beta \\ 0, & otherwise. \end{cases} \quad (1)$$

Objective of The Study

This study aims to determine the different of students' performance in terms of students' result by using fuzzy logic model with the classical methods. The data is collected based on raw marks of 26 foundation students' assessment in Agriscience program, Preparatory Centre for Science and Technology, PPST UMS in their Semester 2, Session 2021/2022 for Mathematics subjects. The whole data is divided into 3 different assessments: Assignments, Midterm examination and Final term examination scores.

Methodology

Research Design

This model comprises of five main stages.
Step 1: Collection of raw data.
Step 2: Fuzzification of input data.
Step 3: Application of rules in the fuzzy logic.
Step 4: Defuzzification of the performance value.
Step 5: Comparison and analysis on the output.

Result and Analysis

Raw Data

Table 1. shows the scored achieved by 26 Agriscience students in Assignment, Midterm examination and Final term examination, as well as their final marks and grade for Semester 2, Session 2021/2022.

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Step 1: The scores is obtained and compiled as shown in Table 1.

Table 1: Scores Obtained by 26 Students in Agriscience Program

No.	Student	Example				
		Assignment	Mid Term	Final Term	Score	Grade
1.	Student 1	76.7	41.9	40.0	57	C+
2.	Student 2	75.4	80.6	70.0	75	A-
3.	Student 3	76.8	22.6	30.0	50	C
4.	Student 4	82.0	83.9	62.9	76	A-
5.	Student 5	70.9	29.0	32.9	50	C
6.	Student 6	77.5	45.2	38.6	58	C+
7.	Student 7	79.0	80.6	51.4	70	B+
8.	Student 8	72.3	51.6	40.0	57	C+
9.	Student 9	81.9	25.8	24.3	51	C
10.	Student 10	81.2	87.1	81.4	83	A
11.	Student 11	82.0	77.4	62.9	75	A-
12.	Student 12	79.0	83.9	81.4	81	A
13.	Student 13	81.2	83.9	58.6	74	B+
14.	Student 14	84.2	93.5	60.0	78	A-
15.	Student 15	82.0	83.9	75.7	81	A
16.	Student 16	84.2	87.1	71.4	81	A
17.	Student 17	79.8	64.5	48.6	66	B
18.	Student 18	77.5	87.1	80.0	81	A
19.	Student 19	79.0	83.9	81.4	81	A
20.	Student 20	81.2	87.1	67.1	78	A-
21.	Student 21	77.5	74.2	67.1	74	B+
22.	Student 22	77.5	83.9	78.6	80	A
23.	Student 23	79.0	87.1	84.3	83	A
24.	Student 24	79.0	61.3	67.1	72	B+
25.	Student 25	79.7	87.1	25.7	63	B-
26.	Student 26	84.2	87.1	67.1	79	A-

Source: (Mathematics Course File, Semester 2, Session 2021/2022)

Step 2: The fuzzification of the students score was carried out by inserting input variables and their membership functions in fuzzy sets. In this paper, input variables are assignment, midterm examination and final term examination. Meanwhile, output variable is total mark of the students. Each input and output employ by using triangular membership values.

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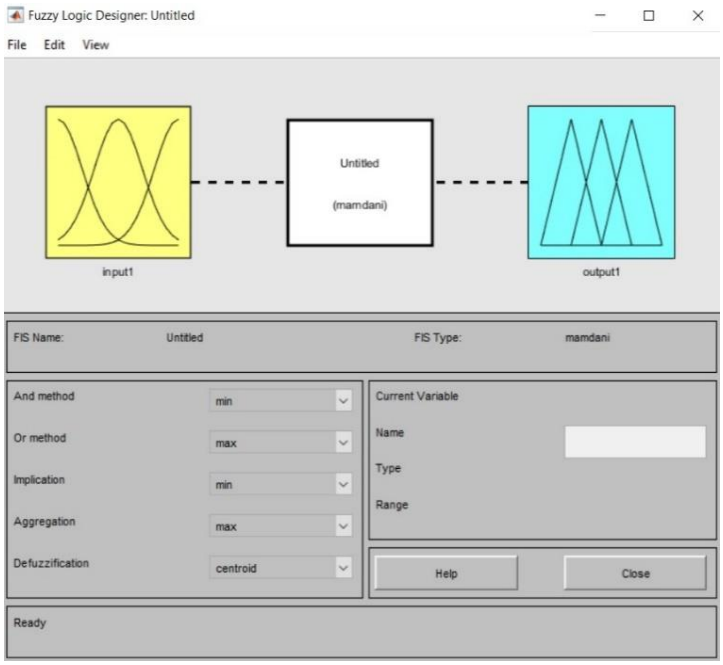

Figure 1: Fuzzy Logic Designer

Source: (Fuzzy logic toolbox, Matlab)

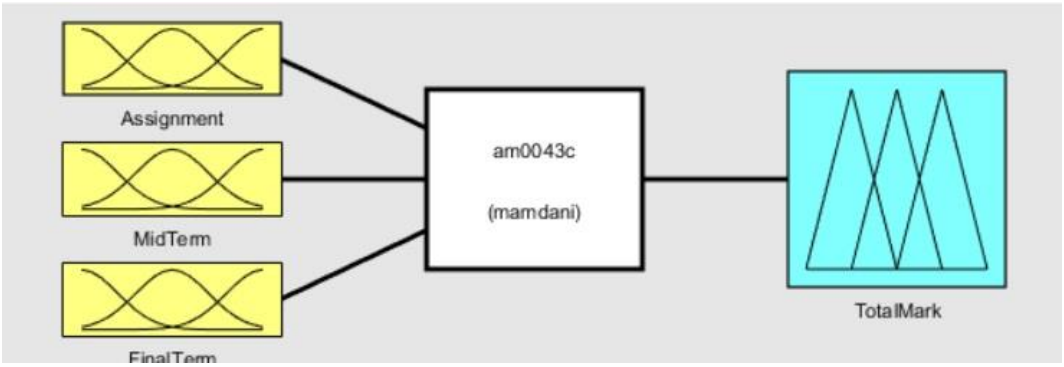

Figure 2: Determination of Students' Performance using Fuzzy Logic

Source: (Fuzzy logic toolbox, Matlab)

The membership of all three inputs has the same interval, thus all will have the same weighted average, as shown in Table 2.

Table 2: Input Variables in The Fuzzy Logic System

Linguistic Expression	Symbol	Interval
Very Low	VL	[0 0 25]
Low	Lo	[0 25 50]
Average	Av	[25 50 75]
High	Hi	[50 75 100]
Very High	VH	[75 100 100]

Figure 3 shows that students' marks can belong to one or two membership functions, but with different weightage. For example, a score of 50 only belong to "Average" membership function. Meanwhile a score of 60 belongs to both "Average" and "High" membership

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function, but it is more heavily belong to "Average" membership function compared to "Low" membership function.

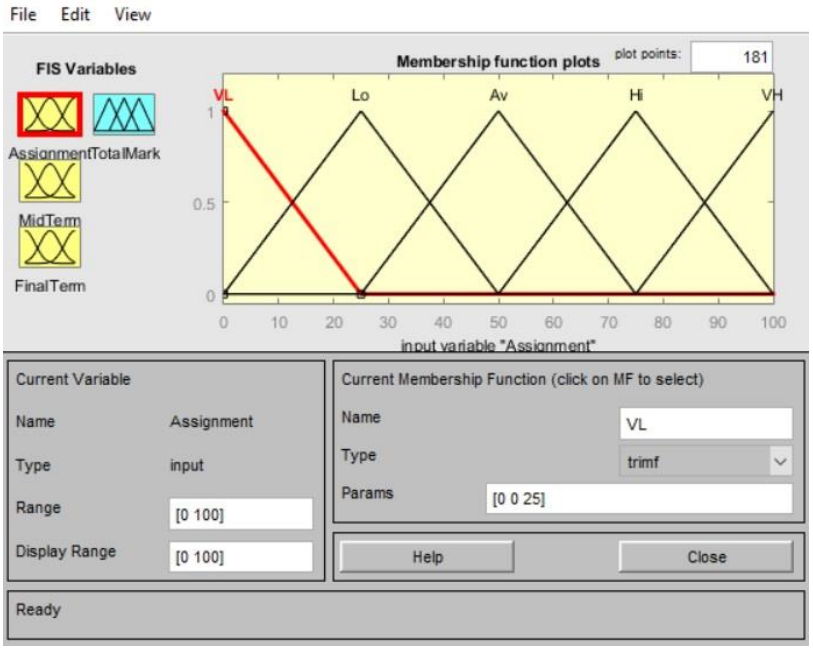

Figure 3: Membership Function of Input Variable 1 (Assignment), Input Variable 2 (MidTerm) and Input Variable 3 (Finalterm)

Source: (Fuzzy logic toolbox, Matlab)

The output variable, which is the students' performance value, is entitled "Total Mark" and has five membership function as well. To apply it easily in this application, we chose a range between 0 and 1 as shown in Table 3 and Figure 4.

Table 3: Input Variables in The Fuzzy Logic System

Linguistic Expression	Symbol	Interval
Very Unsuccessful	VU	[0 0 0.25]
Unsuccessful	Un	[0 0.25 0.50]
Average	Av	[0.25 0.50 0.75]
Successful	Su	[0.50 0.75 1]
Very Successful	VS	[0.75 1 1]

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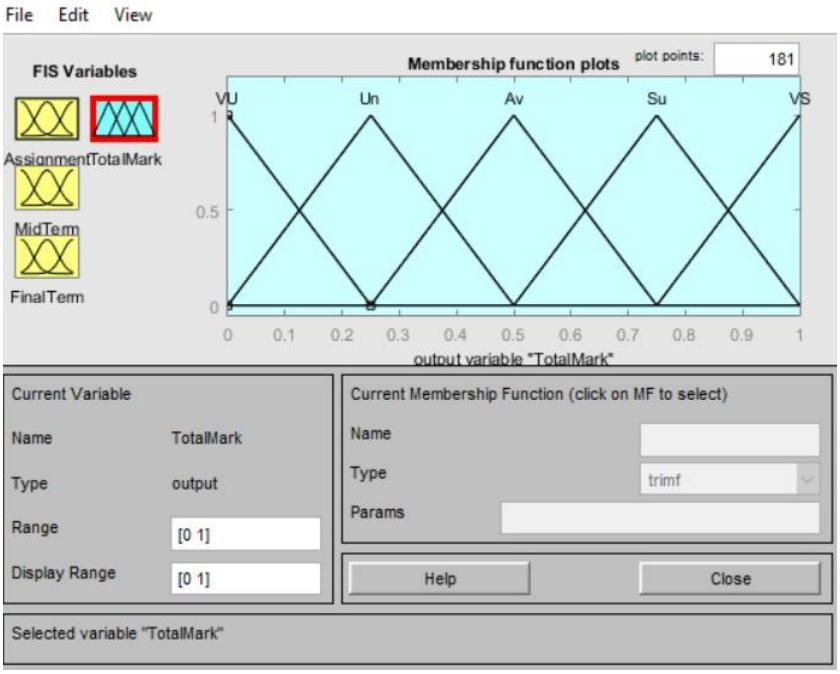

Figure 4: Membership Function of Output Variables (Total Mark)

Source: (Fuzzy logic toolbox, Matlab)

Rules and Inference

Step 3: The application of fuzzy rules in determining input and output membership functions that will be used in inference process as in Table 4 below. These rules entitled *If-then Rules* as in Altrock (1995) and Semerci, (2004).

Table 4: Membership Functions of The Input Variables

Output Variables	**Input Variables**		
	Assignment	**Midterm**	**Final term**
Very Unsuccessful (VU)	Very Low (VL)	Very Low (VL)	Very Low (VL)
	Very Low (VL)	Very Low (VL)	Low (Lo)
	Very Low (VL)	Low (Lo)	Very Low (VL)
	Low (Lo)	Very Low (VL)	Very Low (VL)
	Very Low (VL)	Low (Lo)	Low (Lo)
	Low (Lo)	Very Low (VL)	Low (Lo)
	Low (Lo)	Low (Lo)	Very Low (VL)
Unsuccessful (Un)	Low (Lo)	Low (Lo)	Low (Lo)
	Average (Av)	Low (Lo)	Low (Lo)
	Low (Lo)	Average (Av)	Low (Lo)
	Low (Lo)	Low (Lo)	Average (Av)
Average (Av)	Average (Av)	Average (Av)	Average (Av)
	High (Hi)	Average (Av)	Average (Av)
	Average (Av)	High (Hi)	Average (Av)
	Average (Av)	Average (Av)	High (Hi)
	Low (Lo)	Average (Av)	Average (Av)
	Average (Av)	Low (Lo)	Average (Av)
	Average (Av)	Average (Av)	Low (Lo)
Successful (Su)	High (Hi)	High (Hi)	High (Hi)

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	Very High (VH)	High (Hi)	High (Hi)
	High (Hi)	Very High (VH)	High (Hi)
	High (Hi)	High (Hi)	Very High (VH)
	Average (Av)	High (Hi)	High (Hi)
	High (Hi)	Average (Av)	High (Hi)
	High (Hi)	High (Hi)	Average (Av)
Very Successful (VS)	Very High (VH)	Very High (VH)	Very High (VH)
	High (Hi)	Very High (VH)	Very High (VH)
	Very High (VH)	High (Hi)	Very High (VH)
	Very High (VH)	Very High (VH)	High (Hi)

Source: (*If-then* Rules as in Altrock (1995) and Semerci, (2004))

Determination of The Evaluation Value

Step 4: Defuzzification process will be proceed after completing fuzzy decision process to convert fuzzy number to crisp value. There are various methods in defuzzification, and centroid is one of it. This technique is mainly applied in this study. Crisp value will be obtained and calculated as follows:

$$z^* = \frac{\int \mu_c(z) \times z \times dz}{\mu_c(z) \times dz} \quad (2)$$

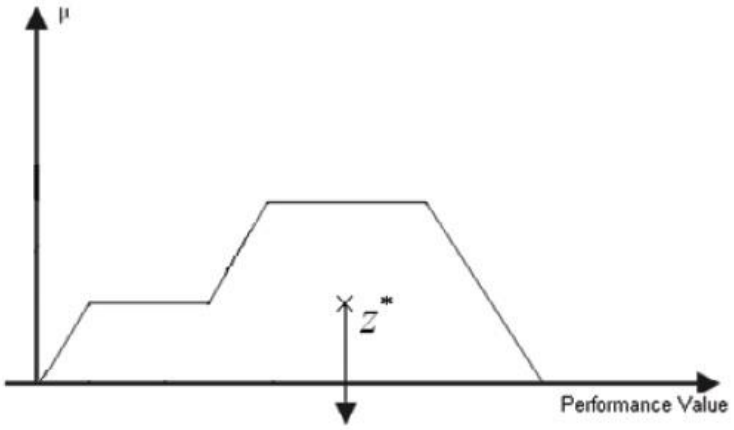

Figure 5: Defuzzification with Centroid Method

Source: (Fuzzy logic toolbox, Matlab)

Results and Discussions

Table 5 show the score achieved from classical method and fuzzy logic approach.

Table 5: Scores Obtained from 26 Students in Mathematics Subject

No.	Student	Classical					Fuzzy logical		
		Assign ment	Mid Term	Final Term	Score	Grade	Output	Score	Grade
1.	Student 1	76.7	41.9	40.0	57	C+	0.500	50	C
2.	Student 2	75.4	80.6	70.0	75	A-	0.750	75	A-
3.	Student 3	76.8	22.6	30.0	50	C	0.500	50	C
4.	Student 4	82.0	83.9	62.9	76	A-	0.763	76	A-

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5.	Student 5	70.9	29.0	32.9	50	C	0.375	38	D
6.	Student 6	77.5	45.2	38.6	58	C+	0.500	50	C
7.	Student 7	79.0	80.6	51.4	70	B+	0.751	75	A-
8.	Student 8	72.3	51.6	40.0	57	C+	0.526	53	C
9.	Student 9	81.9	25.8	24.3	51	C	0.500	50	C
10.	Student 10	81.2	87.1	81.4	83	A	0.761	76	A-
11.	Student 11	82.0	77.4	62.9	75	A-	0.752	75	A-
12.	Student 12	79.0	83.9	81.4	81	A	0.760	76	A-
13.	Student 13	81.2	83.9	58.6	74	B+	0.759	76	A-
14.	Student 14	84.2	93.5	60.0	78	A-	0.773	77	A-
15.	Student 15	82.0	83.9	75.7	81	A	0.761	76	A-
16.	Student 16	84.2	87.1	71.4	81	A	0.770	77	A-
17.	Student 17	79.8	64.5	48.6	66	B	0.641	64	B-
18.	Student 18	77.5	87.1	80.0	81	A	0.757	76	A-
19.	Student 19	79.0	83.9	81.4	81	A	0.760	76	A-
20.	Student 20	81.2	87.1	67.1	78	A-	0.760	76	A-
21.	Student 21	77.5	74.2	67.1	74	B+	0.737	74	B+
22.	Student 22	77.5	83.9	78.6	80	A	0.754	75	A-
23.	Student 23	79.0	87.1	84.3	83	A	0.770	77	A-
24.	Student 24	79.0	61.3	67.1	72	B+	0.655	66	B
25.	Student 25	79.7	87.1	25.7	63	B-	0.750	75	A-
26.	Student 26	84.2	87.1	67.1	79	A-	0.770	77	A-

Source: (Mathematics Course File, Semester 2, Session 2021/2022)

When the results are evaluated, a difference in their final grades is seen between the classical method and the fuzzy logical method. In general, some of the students successful in getting better grade in fuzzy logical method compared to in the classical method. For example, Student 25 got B- using classical method while A- using fuzzy logic approach respectively. Figure 6 shows the active rules and performance value by Student 25. For this student, at the end of defuzzification, a performance value of 0.750 is obtained.

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Figure 6: Active Rules and Performance Value for input 79.7, 87.1, and 25.7
Source: (Fuzzy logic toolbox, Matlab)

Table 6 shows the comparison on students' performance between classical method and fuzzy logic approach.

Table 6: The Comparison of Students' Performance Between Classical Method and Fuzzy Logic Approach

Grade	Range	Classical		Fuzzy logical	
A	80-100	8	30.8%	0	0%
A-	75-79	6	23.1%	17	65.4%
B+	70-74	4	15.4%	1	3.8%
B	65-69	1	3.8%	1	3.8%
B-	60-64	1	3.8%	1	3.8%
C+	55-59	3	11.5%	0	0%
C	50-54	3	11.5%	5	19.2%
C-	45-49	0	0%	0	0%
D+	40-44	0	0%	0	0%
D	35-39	0	0%	1	3.8%
E	0-34	0	0%	0	0%
X	-				
TOTAL		26		26	

Conclusion

From the study, it is found that fuzzy logic evaluation is much more flexible, and it provides more evaluation option. Meanwhile, classical method offers fixed mathematics calculation. At the application stage, this method is flexible to be used by other subject too, and the lecturer may edit the range of membership functions as well as the rules being used, permitting non-homogenous but still flexible and liaise to the objectives of students' performance evaluation.

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References

Altrock, V. C. (1995). Fuzzy Logic Application in Europe, In J. Yen, R. Langari, and L. A. Zadeh (Eds.). *Industrial Applications of Fuzzy Logics and Intelligent Systems, Chicago:. IEEE Press.*

Barlybayev, A., Sharipbay, A., Ulyukova, G., Sabyrov, T. and Kuzenbayev, B. (2016) Student's performance evaluation by fuzzy logic. *Procedia Computer Science*, (102), 98-105.

Biswas, R. (1995). An Application of fuzzy sets in students' evaluation. *Fuzzy Sets and Systems*, 74(2), 187-194.

Chang, D. F. and Sun, C. M. (1993). Fuzzy Assessment of Learning Performances of Junior High School Students. *In Proceedings of the 1993 1st National Symposium on Fuzzy Theory and Applications*, 1-10.

Chrysafiadi, K. and Virvou, M. (2012). Evaluating the Integration of Fuzzy Logic Into the Student Model of a Web-Based Learning Environment. *Expert Systems with applications*, (39), 13127-13134.

Gokmen, G., Akinci, T. C., Tektas, M., Onat, N., Kocyigit, G. and Tektas, N. (2010). Evaluation of Students Performances in Laboratory Applications Using Fuzzy Logic. *Procedia Social and Behavioral Science*, (2), 902-209.

Law, C. K. (1996). Using Fuzzy Numbers in Educational Grading System. *Fuzzy Sets and Systems*, 83(3), 311-323.

Saleh, I. and Kim, S. I. (2009). A Fuzzy System for Evaluationg Students' Learning Achievement. *Journal of expert Systems with Application*, (36), 6236-6243.

Semerci, C. (2004). The Influence of Fuzzy Logic Theory on Students' Achievement. *The Turkish Online Journal of Educational Technology* TOJET, 3(2;9), 1303-6521.

Sen, C. G. and Cenkci, D. (2009). An Integrated Approach to Determination and Evaluation of Production Planning Performances Criteris. *Journal of Engineering and Natural Science*, (27), 4-5.

The Mathworks. (2015). Fuzzy Logic Toolbox User's Guide.

Timothy, J. R. (2004). Fuzzy logic with Engineering Applications. *Chicchester Wext Sussex. UK: McGraw-Hill, Inc.*

Wen, S. and Liu, D. F. (2021). Students' Learning Performances Evaluation Using A New Fuzzy Inference System. *In Proceedings of 2nd International Conference on Artificial Intelligence and Education (ICAIE)*, 650-656.

Zadeh, L. A. (1965). Fuzzy Sets. *Information and Control*, (8), 338-353

Zimmermann, H. J. (2001). Fuzzy Set Theory and Its Applications. *London. Kluwer Academic Publisher.*