Analysis of Academic Performance of Mathematics Students Using Fuzzy Logic

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Received: 14.04.2024 Revised : 22.05.2024 Accepted: 28.05.2024

ABSTRACT
Traditional performance evaluation, which is primarily focused on exam results and frequently yields binary outcomes of pass or fail, is the mainstay of conventional assessment methods in the field of education. This study challenges conventional by presenting novel approaches to performance evaluation, particularly by employing fuzzy logic, a cutting-edge mathematical tool based on set theory that improves decision-making. Our research focuses on the NEP batch's academic performance in an autonomous college, evaluating their theory and practical mathematics scores from semesters I and II. In order to provide a more accurate and dynamic method of evaluating student achievement, this study promotes the use of fuzzy logic.The simulation's results provide strong evidence for the effectiveness of the suggested fuzzy logic-based evaluation technique. Beyond the limitations of conventional pass/fail classifications, the transition towards an elaborate and adaptable assessment framework has the potential to offer a deeper insight of student performance. The study promotes the use of fuzzy logic in educational evaluations in order to provide a more thorough and accurate depiction of students' academic performance.

Keywords: Fuzzy Logic, Academic Performance, Membership function, Fuzzy Inference System, Simulink

1. INTRODUCTION

The success is measured by students' academic performance in every educational institution.Students' performance in higher education is assessed and evaluated in a way that reflects their achievement of the desired learning outcomes. Learning outcomes are intended to specify the competencies that students must possess at the end of the course[1]. Effective teaching and learning are mostly dependent on assessment, which is a systematic process that includes all methods of learning about students' progress [2]. Identification of learning outcome is the initial stage, and an evaluation of those course outcomes accomplished is the crucial stage.A fuzzy expert system was suggested by Yadav, R. S., and Singh, V. P. [3] for evaluating the academic performance of students. It introduced fuzzy logic's guiding principles and gave justification of how educators could use these principles to assess the academic achievement of their students.Saxena, N., &Saxena, K. K [4] concludes that the ranking of any institute always depends on the academics and attendance of its students and the paper provides a methodology to improve these factors by analysing their performance by fuzzy logic system.Petrudi, S. H. J. et. al [5] proposes a meansof evaluation for student academic performance based on fuzzy techniques where universities can revise rules and membership functions to get better outcomes.Fuzzy logic-based reasoning is now employed as one of the methods of managing various types of imperfect score data [6-8]

Fuzzy logic offers a foundation for task modelling, assessment, and optimisation in a variety of contexts, including education and learning. The fuzzy logic theory is one of the truly effective ways to eliminate doubt on the necessity of openness and objectivity in student evaluations[9-11].

Motivated from the above mentioned papers and the research gaps lies in the performance analysis we developed the new methodology with the help of Fuzzy Logic. To Novelty of the paper is

- Fuzzification of inputs and output.
- Inference method
- Defuzzification of performance value.

The above mentioned methodologies are new and will help in to get the exact performance analysis. The rest of the paper is organized as follows; In section 2, the methodology which we adopted has been

elaborated with a flow chat. Fuzzification of Inputs and Outputs are presented with numerical examples are illustrated in Section 3. In section 4, we discuss how our finding challenges the traditional performance analysis. We conclude the paper with conclusion in section 5.

2. METHODOLOGY

Fuzzy set is a classic set development used in fuzzy logic. The traditional set makes it clear when a little change in value results in a substantial change in the status of the value in the set, making it appear unwise and unfair. Fuzzy logic is aimed to represent human reasoning and knowledge based on non – digital set theory and rules. By employing linguistic variables like unsatisfactory, satisfactory, moderate, successful and highly successful, fuzzy logic can deal with vague systems. One common application of fuzzy logic and fuzzy set theory will be the subject of this investigation, which will focus on the fuzzy inference system (FIS). FIS is a rule-based system with if-then rules derived from human experience and knowledge. FIS is classified into three types in which we used MamdaniFuzzy Inference system. It is necessary to convert the fuzzy output from this system into crisp form because it was originally designed to manage a steam engine and boiler combination using a collection of linguistic variables. To accomplish this, various defuzzification methods are applied to transform fuzzy output into crisp
Steps implicating the Fuzzy Methodology is shown in Fig. 1:

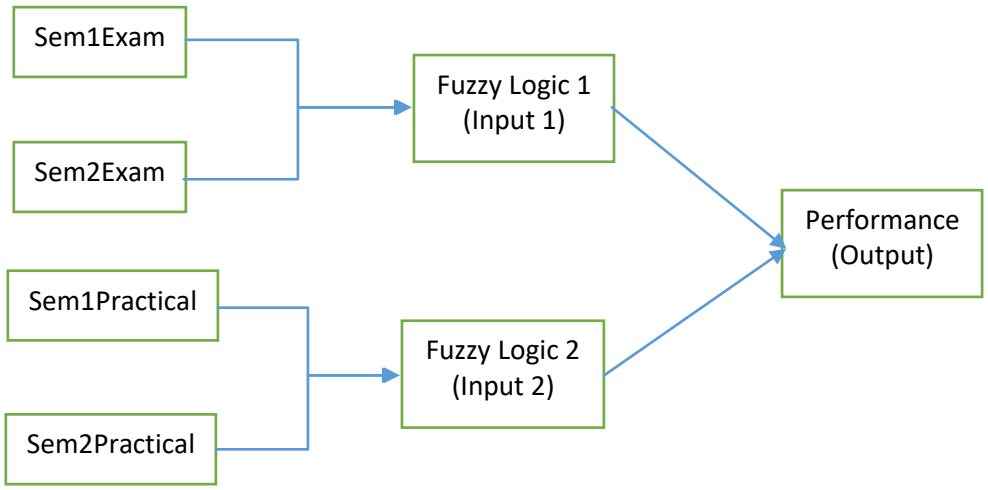

Fig 1. Fuzzy Methodology Diagram

Here, students attended Sem1Exam, Sem2Exam, Sem1Practical Exam and Sem2Practical Exam give rise to four input variables whichleads to two output variables namely Fuzzy Logic 1 and Fuzzy Logic 2 that resulted in performance (output). Fuzzy logic was used in three stages to evaluate academic performance:

1. Fuzzification of inputs and output.
2. Inference method
3. Defuzzification of performance value.

3. Fuzzification Of Inputs And Outputs

Input variables and membership functions are inevitable in fuzzification of input examination outcomes. Every student has four examination results in which each form input variables of the fuzzy logic system. There are five triangular membership functionsspecified by three parameters (a, b, c)for each input variable in the system (Fig. 1, 2,3). The fuzzy sets of the input variables are given in table1.

$$Triangular(x: a, b, c) = \begin{cases} 0 & x \le a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le c \\ 0 & x \ge c \end{cases}$$

Table 1. Fuzzy set of Fuzzy Logic 1(Input 1) and Fuzzy Logic 2(Input 2)

Linguistic variables	Interval
Very Poor (VP)	(0, 0, 25)
Poor (P)	(0, 25, 50)
Average (A)	(25, 50, 75)
Good (G)	(50, 75, 100)
Very Good (VG)	(75, 100, 100)

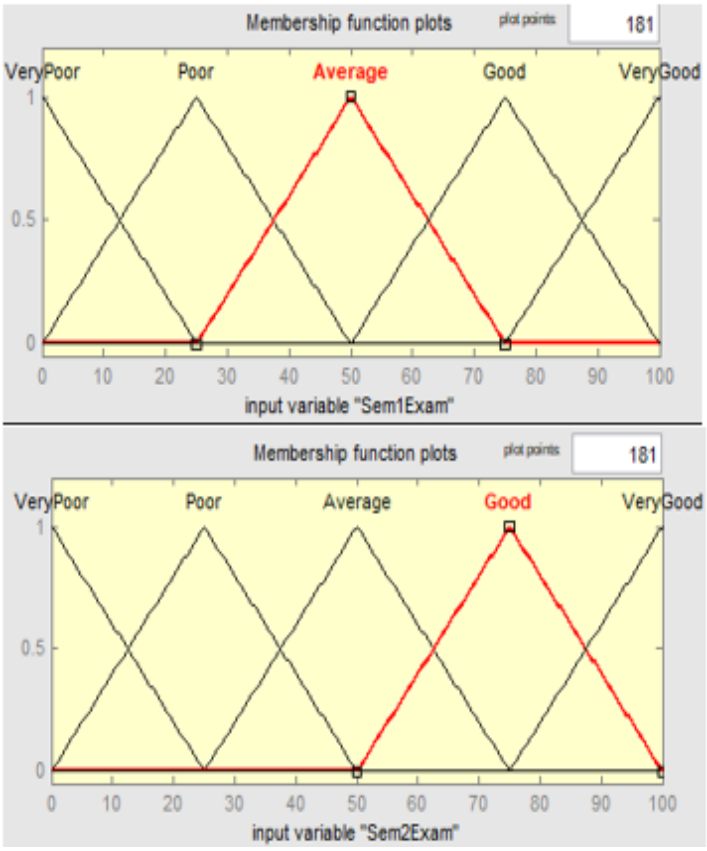

Fig 2. Input 1 Membership function

Table 2. Inference Rule ofFuzzy Logic 1(Input 1) and Fuzzy Logic 2(Input 2)

	Sem1Exam					
Sem2Exam		VP	P	A	G	VG
	VP	US	US	SA	SA	M
	P	US	SA	SA	M	M
	A	SA	SA	M	SU	SU
	G	SA	M	SU	SU	HS
	VG	M	SU	SU	HS	HS

Table 3. Fuzzy set of Input 1 and Input 2

Linguistic variables	Interval
Unsatisfactory (US)	(0, 0, 0.25)
Satisfactory (SA)	(0, 0.25, 0.5)
Moderate (M)	(0.25, 0.5, 0.75)
Successful (SU)	(0.5, 0.75, 1.0)
Highly Successful (HS)	(0.75, 1.0, 1.25)

3.1 Rules And Inference Generation

Fuzzy inference generates an integrated structure of output membership functions by invoking one or more rules based on the input data (Fig. 4, 5, 6).

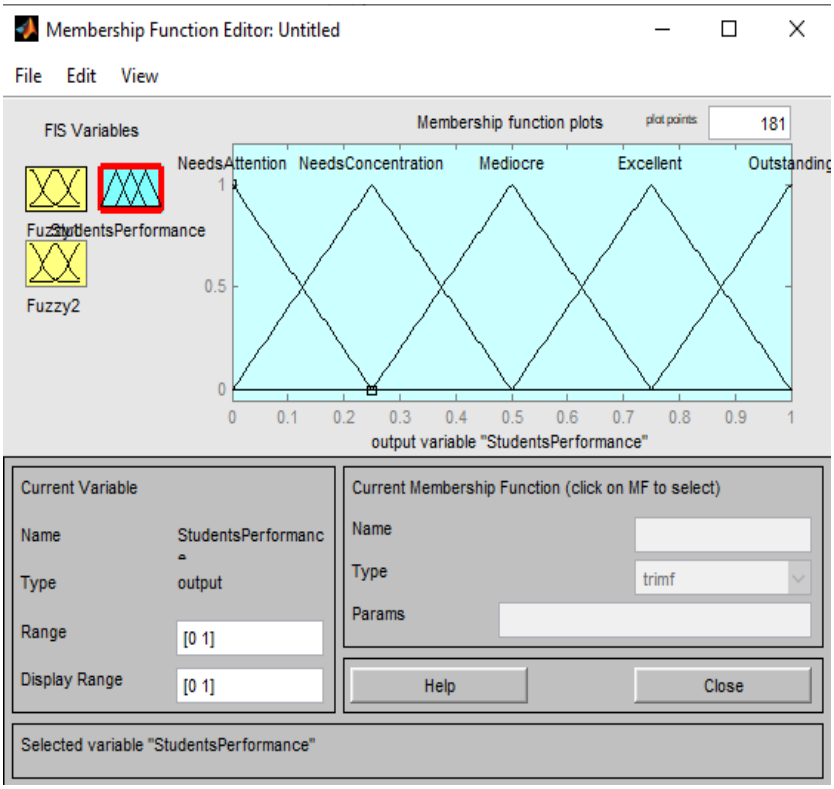

Fig 4. Membership function of Students' Performance

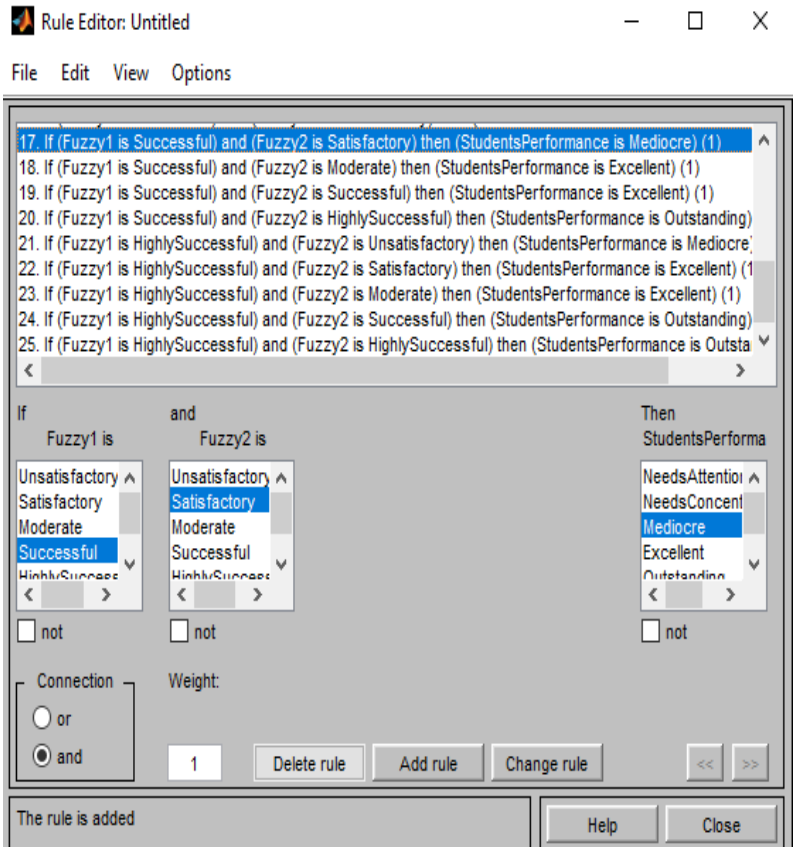

Fig 5. Fuzzy Rules

This corresponds to the fuzzy decision on performance value of a student. In this paper, we use the method proposed by Mamdami that is given below:

$\mu_c = max\{min[\mu_A(input(i), \mu_B(input(j))]\}$

3.2 Experiment Results

This research study uses MATLAB (version R2014a) to implement the proposed FES (Fuzzy Expert System) for evaluating student academic achievement. Fuzzy Tool was employed for this study project.The proposed FES was evaluated using 54 students' math scores from semester 1 and semester 2 exams results. Table 5displays the resultsobtained by 15 BSc II year students in the Department of Mathematics of an autonomous college in Bengaluru, Karnataka, India. The triangle membership functions were used to fuzzify the results of each student's two semester exams. Using Mamdami Fuzzy Decision Techniques, active membership functions are determined in accordance with the rule table. Defuzzification was performed after the output (Performance Value) was calculated. This system was repeated using the semester practical examination scores for each student.

Table 5. Experiment Results 1

Sl. No	Sem1Exam (100)	Sem2Exam (100)	Fuzzy 1
1	52.00	71.00	0.7
2	73.00	90.00	0.797
3	52.00	65.00	0.645
4	34.00	29.00	0.305
5	53.00	79.00	0.752
6	99.00	98.00	0.898
7	44.00	72.00	0.63
8	44.00	38.00	0.379
9	78.00	77.00	0.752
10	45.00	52.00	0.467
11	39.00	51.00	0.402
12	71.00	87.00	0.78
13	20.00	45.00	0.244
14	81.00	90.00	0.797
15	29.00	22.00	0.248

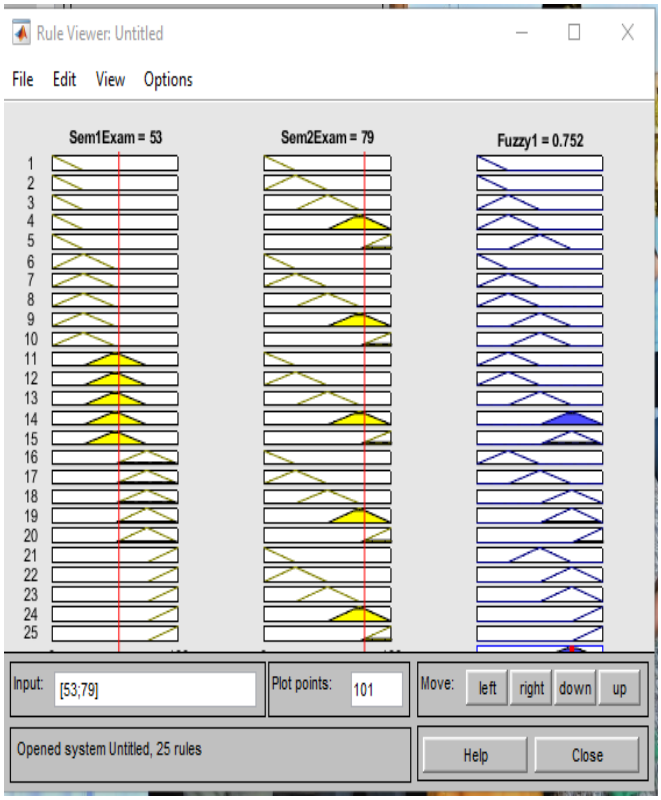

Fig 6. Active rules and performance value of Semester exams

Table 6. Experiment Results 2

Sl. No	Sem1Practical (50)	Sem2Practical (50)	Fuzzy 2
1	82	70	0.761
2	100	100	0.92
3	62	58	0.621
4	66	74	0.734
5	92	88	0.798
6	100	100	0.92
7	90	98	0.867
8	66	66	0.653
9	100	96	0.918
10	70	62	0.678
11	78	68	0.753
12	94	98	0.876
13	68	48	0.637
14	98	100	0.919
15	70	50	0.69

Table 7. Performance evaluation

Sl. No	Fuzzy 1	Fuzzy 2	Performance
1	0.7	0.761	0.75
2	0.797	0.92	0.812
3	0.645	0.621	0.636
4	0.305	0.734	0.727
5	0.752	0.798	0.755
6	0.898	0.92	0.805
7	0.63	0.867	0.779
8	0.379	0.653	0.64
9	0.752	0.918	0.81
10	0.467	0.678	0.669
11	0.402	0.753	0.75
12	0.78	0.876	0.783
13	0.244	0.637	0.625
14	0.797	0.919	0.811
15	0.248	0.69	0.676

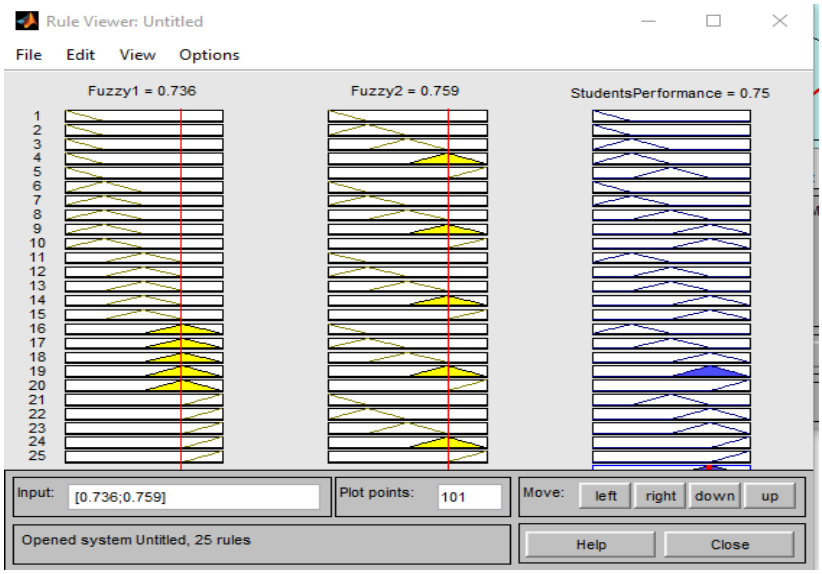

Fig 6. Active rules and performance value

Surface viewer of our proposed study for academic performance evaluation is shown in Fig 6

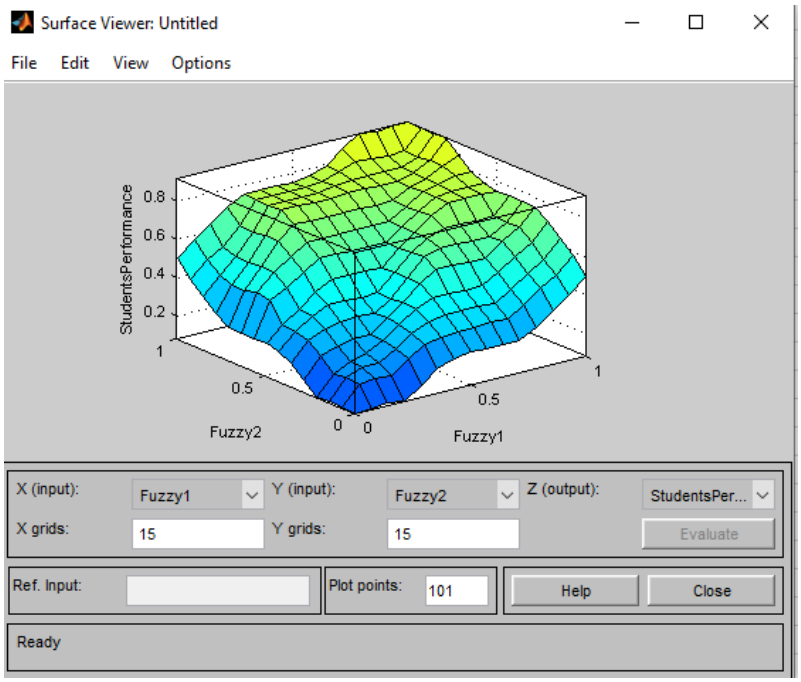

Fig 7. Surface viewer of academic performance evaluation

4. DISCUSSION

It is obvious that the proposed FES facilitates the procedure of examining and assessing student achievement. The challenges of today's competitive climate can be better met by higher education students by identifying their strengths and weaknesses. The fuzzy rules as well as membership function can be improved further to achieve the finest results from fuzzy controllers. To evaluate the performance of faculty, staff, and other people, the suggested technique can also be changed. To evaluate student academic achievement, we have employed soft computing methods like fuzzy logic techniques.

5. CONCULSION

In conclusion, this study has successfully challenged the conventional methods of performance evaluation in the field of education by introducing a novel approach centered around fuzzy logic. The traditional binary outcomes of pass or fail, often derived from exam results, are replaced by a more sophisticated and dynamic evaluation technique. Our focus on the academic performance of the NEP batch in an autonomous college, specifically assessing theory and practical mathematics scores from semesters I and II, has demonstrated the potential of fuzzy logic to offer a nuanced understanding of student achievement. The simulation results strongly support the efficacy of the proposed fuzzy logic-based evaluation system. The findings suggest that this approach can significantly enhance the accuracy and adaptability of the assessment framework, providing a more comprehensive depiction of student performance beyond the limitations of traditional classifications. By incorporating fuzzy logic, we move towards a system that identifies and addresses the strengths and weaknesses of individual students, allowing them to navigate the challenges of a competitive academic environment more effectively.

REFERENCES

[1] Petra, T. Z. H. T., & Aziz, M. J. A. (2021). Analysing student performance in Higher Education using fuzzy logic evaluation. Int. J. Sci. Technol. Res, 10(1), 322-327.

[2] Agarwal, G., Gupta, S., & Agrawal, A. (2019). Evaluation of student performance for future perspective in terms of higher studies using fuzzy logic approach. Int. J. Comput. Appl, 181(50), 9-14.

[3] Yadav, R. S., & Singh, V. P. (2011). Modeling academic performance evaluation using soft computing techniques: A fuzzy logic approach. International Journal on Computer Science and Engineering, 3(2), 676-686.

[4] Saxena, N., &Saxena, K. K. (2010). Fuzzy logic based students performance analysis model for educational institutions. VIVECHAN International Journal of Research, 1, 79-86.

[5] Petrudi, S. H. J., Pirouz, M., &Pirouz, B. (2013, August). Application of fuzzy logic for performance evaluation of academic students. In 2013 13th Iranian Conference on Fuzzy Systems (IFSC) (pp. 1-5). IEEE.
[6] Chua, S. C., Lim, H. S., Oh, T. H., & Pang, S. Y. (2013). On the possibility of fuzzy method and its mathematical framework in OBE measurements. Knowledge-Based Systems, 37, 305-317.
[7] Yadav, R. S., Soni, A. K., & Pal, S. (2014, March). A study of academic performance evaluation using Fuzzy Logic techniques. In 2014 International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 48-53). IEEE.
[8] Surya, A. A., Kurian, M. K., & Varghese, S. M. (2016). Overall performance evaluation of engineering students using fuzzy logic. International Journal on Cybernetics & Informatics (IJCI), 5(2), 71-78.
[9] Amelia, N., Abdullah, A. G., &Mulyadi, Y. (2019). Meta-analysis of student performance assessment using fuzzy logic. Indonesian Journal of Science and Technology, 4(1), 74-88.
[10] W. G. Spady, Outcome-based Education: Critical Issues and Answers. Arlington, VA: American Association of School Administrators, 1994.
[11] L. L. Robert, and E. G. Norman, Measurement and assessment in teaching. Upper Saddle River, NJ: Merrill, 2000.