



Fuzzy Logic Approach in Assessing Students Performance

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Abstract Students performance should be assessed accordingly to ensure that the students are aware of their own strength and weaknesses. In this study, students performance was investigated based on the three factors which are Cumulative Grade Point Average(CGPA), co-curriculum and industrial training as the predictive variable by using fuzzy logic approach. Research is conducted to ten final year students from Faculty of Science, UTM. In spite of that, factor that influenced in assessing student performance was analyzed by using fuzzy set operation to know which the higher and least factor. The result by using fuzzy logic approach was shown that student A, C and D had the same highest and lowest factor which is co-curriculum and CGPA respectively, meanwhile student B and E give a similar result of least influenced factor in performance of student which is industrial training. Moreover, student B had highest influenced factor of CGPA and student E had highest influenced factor of co-curriculum. Student F,G,H,I and J were resulted the similar highest influenced factor of industrial training, meanwhile the least factor that influenced the performance of student F,G,H,I and J is CGPA.

Keywords Fuzzy logic approach ; evaluate performance ; student performance.

1 Introduction

Academic is important to the world. It has contributed on economy and social development in Malaysia. Without academic, Malaysia does not develop with the current technology. At the meantime, the student needs to play a role to perform well in academic. Students are the most important asset for each educational institution. According to Mushtaq & Khan (2012), educational institutions such as universities, colleges and schools will not be worth it without students. Student's academic achievement is also important for the graduates and to get a job as it is also one of the requirements for employers to choose the graduates to work in their place. However, there are several requirements that always be considered in employment such as having soft skills, good in academic and others. Student's performances play an important role in creating the good quality graduates that would be a manpower and great leader who is responsible to develop social and economy of a country (Mushtaq & Khan, 2012).

Meanwhile the actual factor that need to be considered in the evaluation of students performance are CGPA, co-curriculum and industrial training. In this globalization with modern technology, there are many students who are graduated but still unemployed. From this point, the lack of soft skills and working experienced is the one of the factor the graduates not being hired. Moreover, CGPA also is one of the requirement to be employed but CGPA is the least factor in employment . According to the Mushtaq & Khan (2012) there is a way to build soft skill on each student for their performance to have a good quality for being applied in the work environment. At the meantime, there are many factors can contribute to student's performance.

Fuzzy approach is one of the methods that can be used to evaluate student's performance involving several factors in this assessment. There are few terms can used as the student performance's consideration or judgment such as Excellent, Moderate and very low. However, to solve the problem to evaluate performance of student, linguistic term as be used to represent the achievement based on each element of evaluation. To extend this case, fuzzy logic theories are applied on this case to help in handling quantified and interpretation by using unspecific and uncertain values. The objectives of this study are to investigate the performance of students by evaluating based on CGPA, co-curriculum and industrial training by using fuzzy logic approach and to analyze factors that influence in assessing student performance by finding which factors are the highest and lowest in conducting the assessment. Generally, the students involved in this study is ten final year students who have finished industrial training, involved in co-curriculum and have the current CGPA. Advantage of using fuzzy logic approach is it can work with any type of input even contains noise, unstructured, imprecise and distorted and also can work with no data at all.

2 Literature Review

Fuzzy logic has been introduced in 1965 by Lotfi Zadeh . Barlybayev et.al (2016) states that the aim of using this fuzzy logic method is to establish the ability of students without using formulas to predict the performance of student. According to the Ajiboye et.al (2013), fuzzy logic is also known as logic of fuzzy set and and the fuzzy set differs from the Boolean or crispy set as it allows elements to have membership grade which meant the functions of the fuzzy set features can have values between 0 and 1. According to (Kharola et.al, 2015), the elements considered for the whole students assessment are academic, communication, behavioral, presence and co-curricular activities. The important concept in fuzzy logic is the application of lingistic variable which the value are in natural language which are word or sentence. According to Bakae et.al (2012), the process of fuzzy logic was involved in this problem that consists of three procedures which are fuzzy inference process, fuzzification process with included all input and defuzzification process. Fuzzifier maps crisp numbers into fuzzy sets whereas the defuzzifier maps output sets into crisp numbers. The Fuzzy Inference System (FIS) has logic controller which known as Fuzzy Logic Controller ((FLC'c) that construct of data and rule base that formed the knowledge of inference and base engine. In the end, the researcher has achieved on the result from the Matlab-Simulink in comparing the old value of average method and the simulation result. By comparing this both result, the simulation result give a close value as well as result in traditional average method.

There was many various of method in further analysis for evaluate student performance. By the other researcher, Ajiboye et.al (2013) stated that student achievement modeling is a useful tool for both teachers and students, as this can offer help to have a superior understanding of student shortages and lead to improvement. The researcher determined the MAX and MIN function by applying concept of union and intersection of fuzzy operation. Then, to modelling a risk status academic achievement, fuzzy logic approach was used with includes three main task which is

defuzzification, inference and fuzzification. Ajiboye et.al (2013) claimed that they used trapezoidal to represent a membership function. After going through these three main task, result of risk status in academic achievement were obtained. Other than that, Yadav (2011) stated that to investigate the evaluation of student performance in academic by using Fuzzy Expert System (FES) approach. The purposed was to study the student performance in academic by using application of fuzzy modelling based on previous data, creating fuzzy administrative based master frameworks (ES) for such applications, which are math and factual techniques cannot be offered adequately, and that permits derivation to be completed in a more regular manner utilizing etymological factors rather than numeric qualities and conduct experiments on blur rules based on Expert Systems, investigate the effectiveness of methods in handles various attributes, contains incorrect data, to perform human-like corrections (Yadav, 2011). Yadav (2011) defined the meaning of expert systems which is a set of program that manipulates encoded knowledge to solve problem in a specialized domain that normally requires human expertise

Moreover, other than use fuzzy logic , according to Bydzovska (2016), they found that data mining was recently used in solving estimation in final grade of student. According to Anuradha & Velmurugan (2014), educational data mining (EDM) is a rich utility area in data processing and due to the wide availability of educational data, methods and techniques have been developed to analyze data from various educational information systems. This method helps in searching a hidden educational data that is useful for educator and learner. New methods and formats are provided to enhance student's performance by using EDM and also the classification for algorithm was developed to distinguish types of performance's student (Anuradha & Velmurugan,2014).

Apart from that, Bydzovska (2016) proposed two method in predict final grade student which are based on the regression and classification algorithm that find out the behaviour of student and the related with study i.e age, gender and field of study and basis of filtering collaborative method as the second approached. The purpose is to estimated a grades of student with majors of focusing on finding students who cannot meet the requirements for course (Bydzovska,2016). Bydzovska (2016) stated that study- related and student behavior was evaluate by using approach classification and regression.For student behaviour data, the researcher was determined whether the created hypothesis which is the hypothesis assumes that the student's social relationships are related to the student performance and the hypothesis has been confirmed that data on student behavior improves predictions. The second method was implemented using collaborative filtering. This method was give a benefit in requiring data about student grades to make predictions because each university information system stores such data.

Besides that, according to Son et.al (2018), Multi-Input Multi-Output Student Academic Performance Prediction (MIMO SAPP) was predicted the future performance of students after entering the university. Meanwhile, the MIMO SAPP method has limitations of set parameter and inappropriate training strategies. Therefore, Multi Adaptive Neuro-Fuzzy Inferens System with Representative (MANFIS-S) was introduced as a new method in solving the problem in limitation using a set parameter. This method was used a multi parameters set (Son et.al , 2018). MANFIS-S has the advantages as when data sets increase, training time also increases significantly. MANFIS-S accuracy and time is performed according to various parameter values. The discovery will suggest a case and parameter value to be selected in MANFIS-S.Son et.al (2018) suggested that real problems in economy, education and etc should be applied a method of MANFIS as well. This is because MANFIS can executed the data very fast and the multiple parameter that used in modelling this method was more precisely than the other fuzzy models.

3 Mathematical Concept

The mathematical concept used in this study in generating result of performance of student was shown in this section.

Definition 3.1 Fuzzy Set

Let U be a non-empty set, then by a fuzzy set of U meant a function ,

$$A = \{ (x, \mu_A(x) \mid x \in U \}$$

The characteristic function of a crisp set assigns a value of either 1 or 0 to each individual in the universal set, thereby discriminating between members and nonmembers of the crisp set under consideration. The function can indicate the membership grade and assigned a value to the element of the set that defined by fuzzy set. The range of values used in membership function is $[0,1]$.

Definition 3.2 Membership Function of Fuzzy Set

Let A be a set, then the membership function of fuzzy set A is denoted as μ_A ; that is,

$$\mu_A : X \rightarrow [0,1]$$

Definition 3.3 Fuzzy Union

Standard Operation of Fuzzy set of membership function of union A and B can be defined as,

$$\mu_{A \cup B}(x) = \max[\mu_A(x), \mu_B(x)]$$

Definition 3.4 Fuzzy Intersection

Standard Operation of Fuzzy set of membership function of intersection A and B can be defined as,

$$\mu_{A \cap B}(x) = \min [\mu_A(x), \mu_B(x)]$$

Definition 3.5 Fuzzy Logic

The study of the methods and principles of reasoning in all possible forms. Classical logic deals with propositions that are required to be true or false. The proposition have their opposite which called as negation of the proposition that also required to assume opposite truth values.

Definition 3.6 Linguistic Variable

A variable whose values are words or sentences in a natural or artificial language. Linguistic variable can be assigned as one or more linguistic value which are in turn connected to a numeric value through the mechanism of membership function.

Definition 3.7 Fuzzy System

Any system whose variables (or, at least, some of them) range over states that are fuzzy sets. The fuzzy sets are fuzzy numbers and the associated variables are linguistic variables (i.e.: *too small, medium, big*). There is an application of fuzzy system which is called as fuzzy controller.

Definition 3.8 Fuzzy Controller

Fuzzy controller is a computer-based system that emulates the reasoning process of a human expert. It is varying substantially according to the nature of the problems that are supposed to solve. It is also contrary to the classical controller which capable of utilizing knowledge elicited from human operators.

Fuzzy controller have three main task such as ,

- 1) Fuzzifier,
- 2) Inference,
- 3) Defuzzifier.

Definition 3.9 Linguistic Modifier

Let A be a fuzzy set in U . Then very A is defined as a fuzzy set in $U_{\bar{w}}$ the membership function,

$$\mu_{veryA}(x) = [\mu_A(x)]^2$$

and more or less A is a fuzzy set in $U_{\bar{w}}$ the membership f_n ,

$$\mu_{more\ or\ less\ A}(x) = [\mu_A(x)]^{\frac{1}{2}}$$

4 Methodology

In this section, the methodology in evaluating students performance by using fuzzy logic approach was shown.

4.1 The Flow of Fuzzy controller In Solving Evaluating Students Performance

The fuzzy logic approach is used to generate an overall result in determining student's performance. The method that suitable to use to model of this natural behaviour problem is based on fuzzy theory approach (fuzzy logic system). There are three main task that involves in fuzzy theory approach namely fuzzification, inference and defuzzification. The whole step involves in this approach are illustrated in the Figure 4.1 below.

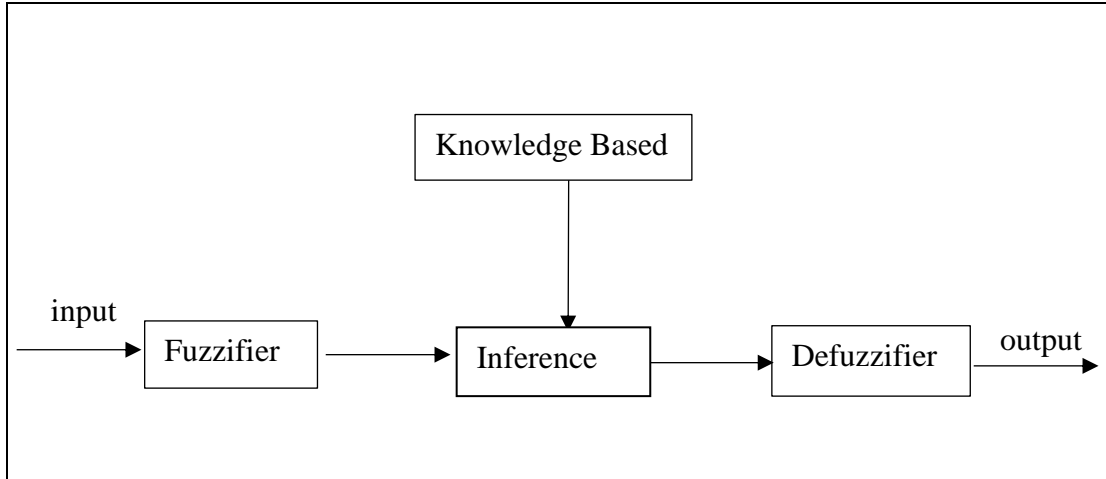


Figure 4.1 Fuzzy logic system for input/output

- Step 1 : Process of identifying of input variables of the controller – collected data among UTM student.
- Step 2 : Analyse the data with using fuzzy set and fuzzy set operation (union, intersection
- Step 3 : The three main task of fuzzy logic system which shown in Figure 4.1 involves to model a result of student’s performance.
- Formed a fuzzy set from the data collected.
 - Illustrate the set in a graph of membership function using the linguistic value and variable that was assigned.
 - Interpreted fuzzy set of linguistic variable.
 - Process of fuzzifier is need to find a membership value from [0,1] through all the input to transformed it to another set.
 - Process of defuzzifier is a reduction to produce a final single result.
- Step 4 : Lastly, apply the the MAX and MIN function to make a decision on the performance of students.

4.2 Data set and data preparation

The collected data among ten students from Faculty of Science are shown in Table 4.1. In this pre-beginning analysis, this data is important to make sure the result will be obtained and model. There are many factors that contributed on evaluation of performance of student other than result of CGPA, involvement in curricular and involvement in training industry.

Table 4.1 Data of student

No	Student	Result of Students		
		CGPA	Co-Curriculum	Industrial Training
1	A	2.45	A+	HL
2	B	3.59	A	HL
3	C	3.04	A	HL
4	D	3.19	A	HL
5	E	3.30	A	HL
6	F	3.48	A+	HL
7	G	2.61	A+	HL
8	H	2.95	A	HL
9	I	2.97	A	HL
10	J	3.22	A	HL

4.3 Analysis Data Into Fuzzy Set Operation

A linguistic variable is transformed to a value which consist of range [0,1] by assigned following linguistic variable to a membership value.

Let CGPA be define as a Fuzzy Set A :

$$\mu_A(x) = p(x)$$

Let Co-Curriculum be define as a Fuzzy Set B :

$$\mu_B(x) = p(x)$$

Let Industrial Training be define as a Fuzzy Set C :

$$\mu_C(x) = p(x)$$

Membership value of fuzzy set A , B and C was assigned based on the appropriate value. Membership degree of A , B and C are :

$$A = \{ (1,0.5), (2,1), (3,0.8), (4,0.8), (5,0.8), (6,0.8), (7,0.7), (8,0.7), (9,0.7), (10,0.8) \}$$

$$B = \{ (1,1), (2,0.95), (3,0.95), (4,0.95), (5,0.95), (6,1), (7,1), (8,0.95), (9,0.95), (10,0.95) \}$$

$$C = \{ (1,0.85), (2,0.85), (3,0.85), (4,0.85), (5,0.85), (6,0.85), (7,0.85), (8,0.85), (9,0.85), (10,0.85) \}$$

This membership degree can illustrate by Figure 4.2, 4.3 and 4.4.

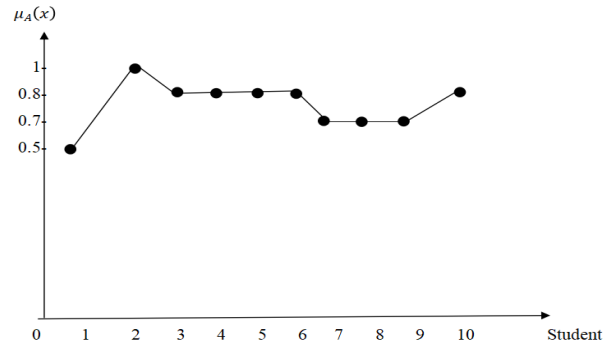


Figure 4.2 Membership graph of Fuzzy Set A

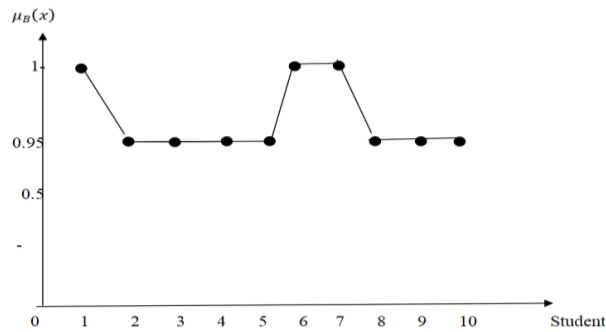


Figure 4.3 Membership graph of Fuzzy Set B

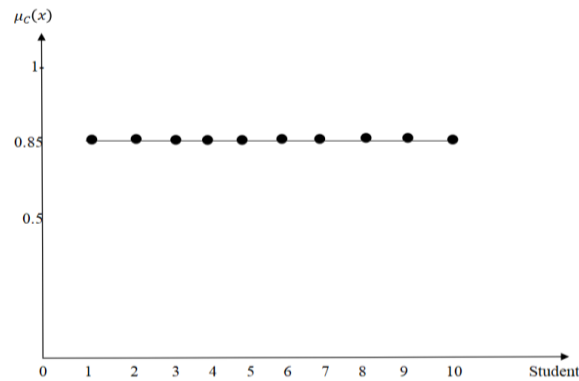


Figure 4.3 Membership graph of Fuzzy Set C

4.4 Approach Model for Result of Student Performance

This approach will going through the process of the three main task :

- 1) Fuzzifier,
- 2) Inference,
- 3) Defuzzifier.

The collected data of student represent the input for this system. Fuzzy set of A, B and C has developed to create a membership function which range from 0 to 1. The membership value of overall data set A, B and C are used in find out the probability of assessment by getting the summation of each membership value from A, B and C divided by three which is the fuzzy set.

Let this probability as function of f .

The degree of membership function is as follows:

$$f(x) = \left\{ \frac{0.783}{1}, \frac{0.933}{2}, \frac{0.867}{3}, \frac{0.867}{4}, \frac{0.867}{5}, \frac{0.883}{6}, \frac{0.85}{7}, \frac{0.833}{8}, \frac{0.833}{9}, \frac{0.867}{10} \right\}.$$

Let linguistic modifier denoted as verylow_performance, moderate_performance and excellent_performance. This linguistic modifier has a range between [0,1] that represent a student's performance.

By getting the probability f function, it gives a probability of assessment of student whether achieved verylow_performance, moderate_performance and excellent_performance. Apart from that, to determine the performance of student by looking at the value of probability of f which obtain before. Hence, let student who has probability 0.49 below is fulfill the criteria in verylow_performance, probability 0.5 is fulfill in moderate_performance and probability 0.51 above fulfill in excellent_performance. The pattern of linguistic modifier with it membership value are follows the Table 4.2.

Table 4.2 Transform to linguistic modifier.

Linguistic Modifier	Membership Value
Excellent_performance	0.51 - 1.0
Moderate_performance	0.50
Verylow_performance	0.49 - 0.0

Figure 4.5 shows the membership graph of $f(x)$ that represent by ,

$$f(x) = \begin{cases} 0.15x + 0.633 & 1 \leq x \leq 2 \\ -0.066x + 1.065 & 2 \leq x \leq 3 \\ 0.867 & 3 \leq x \leq 5 \\ 0.016x + 0.787 & 5 \leq x \leq 6 \\ -0.0167x + 0.9669 & 6 \leq x \leq 9 \\ 0.034x + 0.527 & 9 \leq x \leq 10 \\ 0 & otherwise \end{cases}$$

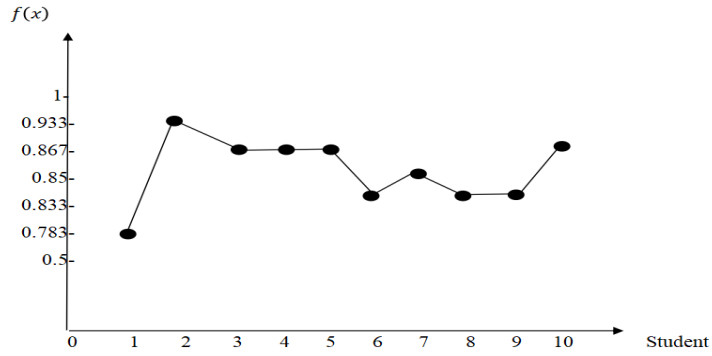


Figure 4.5 Membership graph.

By then, classified the membership value into linguistic modifier by referring Table 4.2. The Figure 4.6 was shown the achievement performance of each student. Student 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 achieve an excellent performance based on the Figure 4.6.

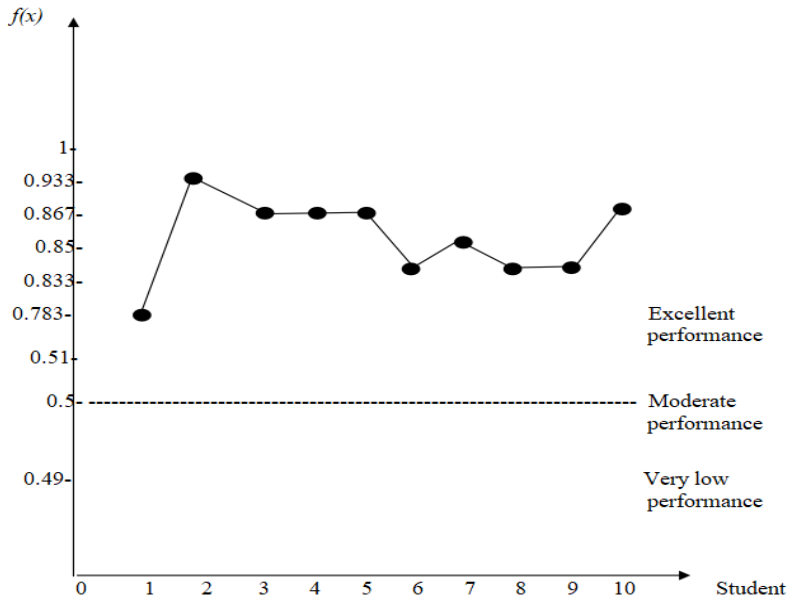


Figure 4.6 Achievement in student performance.

From Figure 4.6, the factor that influenced the performance of student will find out by process of fuzzification. The MAX and MIN values was determined by using concept of fuzzy union and intersection.

Table 4.3 MAX and MIN values in overall performance based on the set A, B and C.

No	Values of	
	MAX	MIN
1	1	0.5
2	1	0.85
3	0.95	0.8
4	0.95	0.8
5	0.95	0.8
6	1	0.8
7	1	0.7
8	0.95	0.7
9	0.95	0.7
10	0.95	0.8

By using Table 4.3 which already find out the values of both function , that values was represent by a name of factor which is set A (CGPA),B (Co-Curriculum) or C (Industrial Training) as shown in Table 4.4. This transformation was know as defuzzification process.

Table 4.4 Classification of MAX and MIN value regarding to the factor.

No	Name of the factor that determined the MAX value	Name of the factor that determined the MIN value
1	Co-Curriculum	CGPA
2	CGPA	Industrial Training
3	Co-Curriculum	CGPA
4	Co-Curriculum	CGPA
5	Co-Curriculum	Industrial Training
6	Co-Curriculum	CGPA
7	Co-Curriculum	CGPA
8	Co-Curriculum	CGPA
9	Co-Curriculum	CGPA
10	Co-Curriculum	CGPA

5 Results

Based on the part analysis, Table 4.4 stated that student A has achieved excellent performance which the most highest factor that influenced the evaluating in performance is curricular meanwhile in Table 4.12 stated that CGPA has least influenced for their achievement in performance. By then, this is meant that student A has more skills and active in co-curriculum.

Moreover, student B has achieved excellent performance with getting higher in CGPA but least in industrial training. From this, student B has shown that they are good in academic but have a basic skills from their previous experienced in industrial training. Apart form that, based on that table, student C, D, E , F ,G, H ,I and J has recorded results with excellent performance. All these students have different least factors that have influenced in assessing their performance. Then, student C,D,F,G,H,I and J have a same least factor in assessing student performance which is CGPA. It meant that student C,D,F,G,H,I and J does not perform well in academic but they can

still achieved excellent performance with do well in co-curriculum. Same goes to the student E, v_5 which did well in co-curriculum but have a lest factor of industrial training.

Hence, the overall result of of achievement of student performance and the factor that influenced the achievement can be illustrated by graph in Figure 4.6. The value of MAX and MIN function have to convert into percentage by using the general formula i.e Probability of MAX/ MIN \times 100. The graph to represented the result was shown in Figure 5.1.

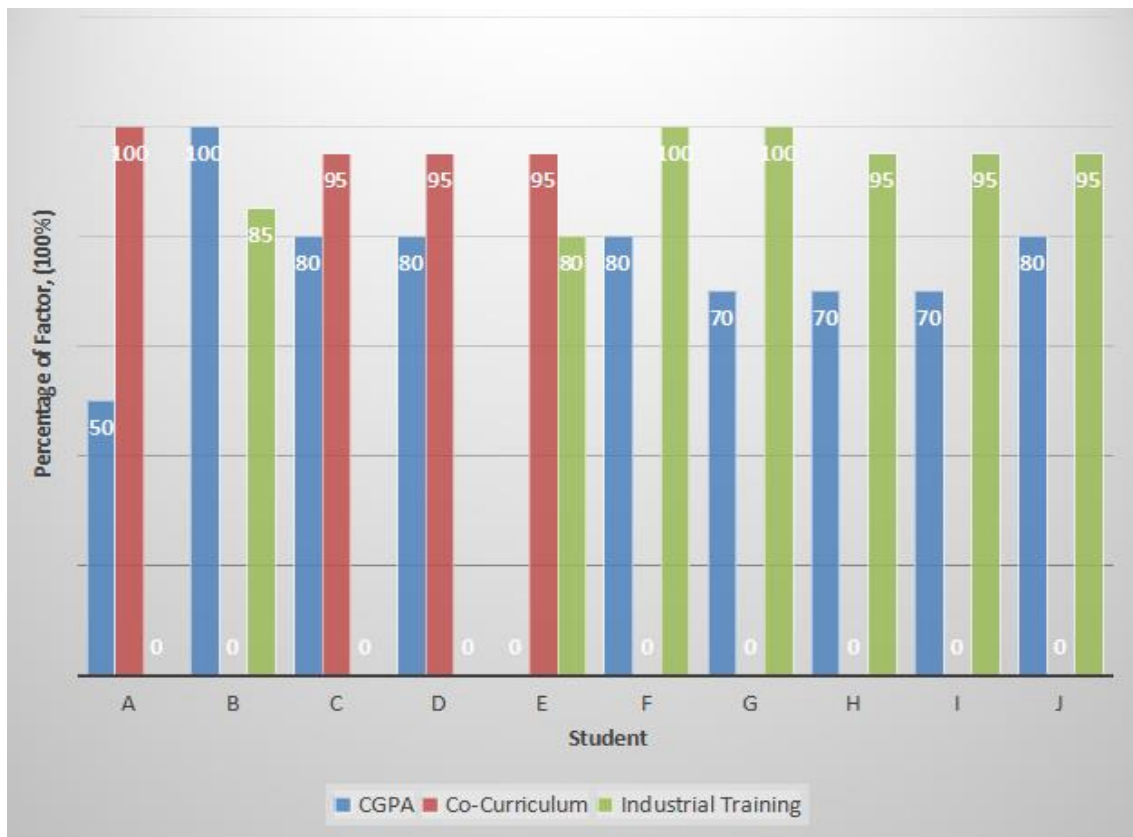


Figure 5.1 Graph to represent the percentage of factor

6 Conclusion

This study aims to determine the performance of student based on three factor which are CGPA, co-curriculum and industrial training and to classify which give higher and less factor affect in influenced assessing in student performance. By applying method of fuzzy logic approach, the process in analyse the data was easier because the method is suitable in calculate the natural human language. There are three main tasks in processing fuzzy logic methods such as fuzzification, inference and defuzzification. In this study, only three factors that used as measuring in performance of student. There are many other factors that can be applied in assessing student performance. This research is a qualitative case which all the data, variables and result use a word or sentence. Based on the analysis, it gives a result in evaluating performance of ten students. Fuzzy linguistic modifier was created to facilitate in determine the level of performance of each student. The linguistic modifier has included verylow_performance, moderate_performance and

excellent_performance. Based on the result obtain in Table 4.8, it has shows that student A,B,C,D,E,F,G,H,I and J has achieved excellent_performance. This was a logic result because based on their previous data collected, some of student are good in CGPA, some of them good in co-curriculum and also some of them good in industrial training. The factor that influenced student performance are very important measured in estimating their performance. The student should know that experienced in industrial training and involvement in co-curriculum is also important for them. It is the extra skills for them if the achieved good in CGPA, co-curriculum and industrial training. This kind of the factor will used in seeking a job as extra skill since right now there are still have unemployed graduated because company is finding a demand skills in hired a workers. As the early step, student must have a good knowledge, skill and experienced in co-curriculum and industrial training instead of only pursue a good CGPA. It will help in getting a job easily. However, based on Figure 5.1, student A, C and D had the same highest and lowest factor which is co-curriculum and CGPA respectively, meanwhile student B and E give a similar result of least influenced factor in performance of student which is industrial training. Moreover, student B had highest influenced factor of CGPA and student E had highest influenced factor of co-curriculum. Student F,G,H,I and J were resulted the similar highest influenced factor of industrial training, meanwhile the least factor that influenced the performance of student F,G,H,I and J is CGPA.

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