EVALUATION OF DISTANCE LEARNING STUDENTS PERFORMANCE USING FUZZY LOGIC

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Abstract

The availability of Internet has accorded people with the opportunity to get education via Distance Learning. Universities, companies even people have their own online teaching tools. Indeed, learners or people who have business with these institutions want to know the quality of their services and how successful they are. This reason is vital to the institutions in getting ranked and rated in our competitive and challenging world. According to many research works measurement of student performance has a great value to rate and rank educational institutions. In this approach we develop a new measuring methodology of student performance for Distance Learning Institutions based on fuzzy logic. We divided Student Performance into major and additional factors. Major factor contains four sub-parameters and additional consists of three sub-parameters. In our view, it is very necessary to scale these seven factors to be able to get accurate results. The nature of fuzzy logic makes scaling easy to the above mentioned parameters which could lead to the achievement of the expected outcomes and result. However, essence of fuzzy logic cannot be over emphasized.

Keywords: Student Performance Evaluation, Fuzzy Logic, Fuzzy Operators and Reasoning, Linguistic Variables and Rules, Membership Function.

1. Introduction

Due to the importance of careers or willingness to gain new skills and to keep one's knowledge up-to-date, there is need for people to always learn. Today's Internet provides a huge amount of online educational resources and tools anywhere and anytime of the day. There are solid relations between students and institutions. Students expect the things more and more in their favor or support from the institution and vice versa. Reputed institutions focus on the performance of their students and try to do it better, so that they could stand in rank position as compared to the other institutions (Neetesh Saxena and Kajal Kaushal Saxena, 2010). Many research works have been done to evaluate student performance using fuzzy logic based on formal (normal) education. Researchers used a maximum of four parameters to ascertain the performance. However, this research seeks to explore several parameters to evaluate and critically assess the performance of distance learning, and not formal (normal) educational students. There are seven factors, on which the performance of distance learning students mostly depends: Homework, Quiz, Middle Examination, Final Examination, Watched Video Lessons, Read E-Book, and Virtual Class Attendance. Each parameter has its own weight proportion which can be set flexibly. Flexibility of fuzzy login helps to measure students' educational performance accurately. In the current application, percentages that are used as values of weight proportion have been recommended by our university distance learning department.

2. Relevant Literature

There have been several research on ways and means of evaluating and predicting students' performance in education. Yıldız et al. (2013) offered an early prediction of student performance during the course. To predict student's early performance he uses data collected within 8 weeks as variables and develop a prediction model based on fuzzy logic. Yadav and Singh (2012) developed a new decision making expert system with fuzzy logic techniques using student's progress and his/her ability in the contrast with the existing classical methods. A research team from Malaysia suggests a new approach scaling to student performance with three parameters such as Academic Examination Point (i.e. CGPA), Industrial Training, Extra Co-Curricular Activities using fuzzy logic (Nureize Arbaiy, 2006). In another study Gokmen et al. (2010) proposes to evaluate student performance based on two parameters such as exam1 and exam2. Pierrakeas et al (2004) monitored academic performance of students within the academic years measuring homework assignments, and implemented short rules that explain success and predict success or failure in the final exams. Ibrahim and Rusli (2007) used neural network, decision tree, and linear regression to estimate students' academic performance. Most part of previous research works intended to measure student's performance based on normal (formal) education not distance learning education and a limited number of factors such as exam 1, exam 2 and attendance.

3. Fuzzy Systems

3.1. Fuzzy set theory

Fuzzy set theory is built on partial memberships (e.g. an individual is a 0.65 member of a set, an action is 75% true) while the traditional set theory is based on if a value absolutely belongs to a set or not, such as "0 or 1","false or true" and "good or bad". In classic rating system if a student gets 50 he/she can pass a course, and a student gets 49 she/he fails, because 50 belongs to successful score sets a hundred percently, 49 belongs to failed score set 100%. But in fuzzy logic success or failed limit rate belongs to a set partially not absolutely. The fuzzy set and logic approach was first invented by the 100% member of the University of California, Dr. Lotfi Zadeh in the 1960s. During his research works on natural languages, he detected that there are cases which

cannot be absolutely true or false. For instance, the word "can" might be understood as "permission", "container", "prison" or a person is 40 years old, he/she is not exactly young or old. Assume that F_A is characteristic function of a fuzzy and classical set A. X is an input parameter of functions.

Expression 1. Functional description of sets

$$F_A(x) = \begin{cases} 1 & \text{if } x \in A \\ 0 & \text{if } x \notin A \end{cases} \qquad \mu_{Fa}(x) = \begin{cases} \dfrac{x-5}{2}, & \text{if } 5 < x \leq 7 \\ \dfrac{2x-5}{3}, & \text{if } \dfrac{5}{3} \leq x \leq \dfrac{2}{3} \end{cases}$$

 a)Classical description of a function.   b) Fuzzy description of a membership function.

3.2 Fuzzy logic

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Its ultimate goal is to provide foundations for approximate reasoning using imprecise propositions based on fuzzy set theory, in a way similar to the classical reasoning using precise propositions based on the classical set theory (Guanrong Chen and Trung Tat Pham, 2001). Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

4. Fuzzy Operators and Reasoning

In order to easily manipulate fuzzy sets, we are redefining the operators of the classical set theory to fit the specific membership functions of fuzzy logic for values strictly between 0 and 1.

Unlike the definitions of the properties of fuzzy sets that are always the same, the definition of operators on fuzzy sets is chosen, like membership functions. Here are the two sets of operators for the complement (NOT), the intersection (AND) and union (OR) most commonly used (Franck Dernoncourt, 2013).

Table 1. Important Fuzzy Logic Operators.

Name	Intersection AND: $\mu A \cap B(x)$	Union OU: $\mu A \cup B(x)$	Complement NOT: $\mu \tilde{A}(x)$
Zadeh Operators MIN/MAX	$\min(\mu A(x), \mu B(x))$	$\max(\mu A(x), \mu B(x))$	$1 - \mu A(x)$
Probabilistic PROD/PROBOR	$\mu A(x) * \mu B(x)$	$\mu A(x) + \mu B(x) - \mu A(x) * \mu B(x)$	$1 - \mu A(x)$

In fuzzy logic, fuzzy reasoning, also known as approximate reasoning, is based on fuzzy rules that are expressed in natural language using linguistic variables which we have given the definition above. A fuzzy rule has the form: If $x \in A$ and $y \in B$ then $z \in C$, with A, B and C fuzzy sets.

For example: "If (the quality of the food is delicious), then (tip is high)".

The variable 'tip' belongs to the fuzzy set 'high' to a degree that depends on the degree of validity of the premise, i.e. the membership degree of the variable "food quality" to the fuzzy set "delicious ". The underlying idea is that the more propositions in premise are checked, the more the suggested output actions must be applied. To determine the degree of truth of the proposition fuzzy 'tip will be high', we must define the fuzzy implication (Franck Dernoncourt, 2013).

5. Linguistic Variables

Variables in math based computing generally get numerical values, but in fuzzy logic, variables take linguistic variables. A fuzzy system is a static nonlinear mapping between its inputs and outputs (i.e., it is not a dynamic system). Assume, there are inputs $x_i \epsilon \{x_1,…,x_n\}$ and outputs $y_i \epsilon \{y_1,…,y_n\}$. Xi inputs and Yi outputs are not fuzzy linguistic variables, but they are "crisps" which are converted to fuzzy inputs and outputs so that they can be handled with fuzzification and defuzzification tools. It can be seen in Figure 1.

Figure 1. Fuzzy Measurement System.
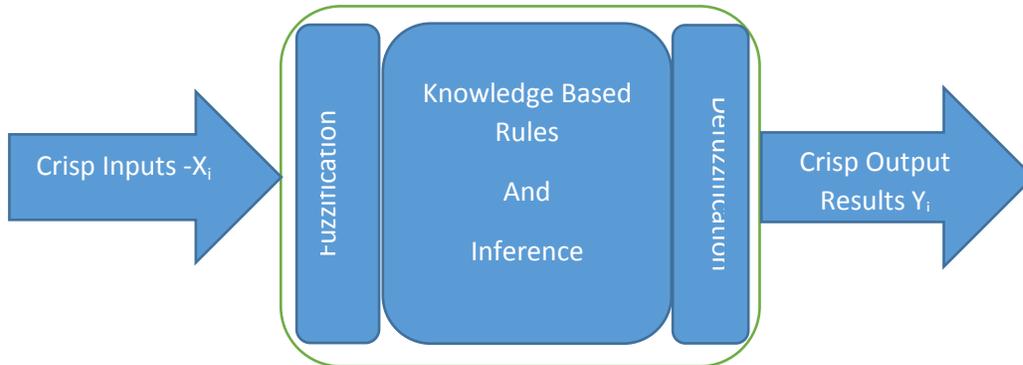
We have seven crucial factors as input crisps or fuzzy linguistic variables: "Homework", "Quiz", "Middle Examination", "Final Examination", "Watched Video Lessons", "Read E-book", "Virtual Class Attendance" and an outcome "Student Performance". They are well described in the table 2 and the table 3.

Table 2. Input linguistic variables for the Student Performance Measurement System.

Homework	Quiz	Middle. Exam	Final	Watched Video Lessons	Read E-Books	Virtual Class Attendance
Very Less	Very Less	Very Less	Very Less	Very Less	Very Less	Very Less
Less	Less	Less	Less	Less	Less	Less
Medium	Medium	Medium	Medium	Medium	Medium	Medium
High	High	High	High	High	High	High
Very High	Very High	Very High	Very High	Very High	Very High	Very High

Table 3. Output linguistic for the Student Performance Measurement System.

Failed	Weak	WeakNormal	Normal	NormalGood	Good	GoodExcellent	Excellent

6. Membership Functions

The membership function of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, it represents the degree of truth as an extension of valuation. Degrees of truth are often confused with probabilities, although they are conceptually distinct, because fuzzy truth represents membership in vaguely defined sets, not likelihood of some event or condition (Wikipedia). In other words, membership functions $\mu A(x)$ are the values or degrees of values of linguistic variables. Following, we define membership functions and mathematical proportions of them for the current evaluation system.

$\mu_i(g*x)$Student Performance=$\{\mu(h*x)$Homework , $\mu(q*x)$Quiz $\mu(m*x)$Middle Examination, $\mu(f*x)$Final Examination , $\mu(w*x)$Watched Video Lessons, $\mu(r*x)$Read E-Book, $\mu(v*x)$Virtual Class Attendance $\}$. Here, g is general performance, h-homework, q-quiz, m-middle examination, f-final examination, w-watched video lessons, r-read e-book and v-virtual class attendance proportions. And other parameters percentages are as follows: h=10%, q=10%, m=20%, f=40%, w=5%, r=5%, v=10%, and the sum of all of them g equals to 100%. There is one independent coefficient n=1 to determine the proportions. $\mu_i(x)$- is here output value or crisp of the student performance membership function and i is the index of the output membership function with the range between 1 and 5 or iϵ[1..5].

Expression 2. Input parameters and output membership functions

$$\mu_i(x) = \begin{cases} 0.25, & \text{if } 0 \leq x \leq 5n/20, \\ 0.45, & \text{if } n/5 \leq x \leq 9n/20, \\ 0.65, & \text{if } 2n/5 \leq x \leq 13n/20, \\ 0.85, & \text{if } 3n/5 \leq x \leq 15n/20, \\ 1.00, & \text{if } 4n/5 \leq x \leq n, \end{cases}$$

The table 4 gives clearer description for input membership functions.

Table 4. Input crisps.

Homework	Quiz	Middle Exam	Final Exam	Watched Video Lessons	Read E-Books	Virtual Class Attendance
Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)
Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)
Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)
High (60-85)	High (60-85)	High (60-85)	High (60-85)	High (60-85)	High (60-85)	High (60-85)
Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)

Table 5. Student Performance as an outcome crisp.

Failed	Weak	WeakNormal	Normal	NormalGood	Good	GoodExcellent	Excellent
(0-49)	(50-57)	(58-64)	(65-74)	(75-79)	(80-84)	(85-89)	(90-100)

7. Developing Rules

The mapping of the inputs to the outputs for a fuzzy system is in part characterized by a set of condition action rules, or in modus ponens (If-Then) form, If premise Then consequent. Usually, the inputs of the fuzzy system are associated with the premise, and the outputs are associated with the consequent. These If-Then rules can be represented in many forms. Two standard forms, multi-input, multi-output (MIMO) and multi input single-output (MISO) are popular. MISO method is used for our approach. For instance: IF x1 is µ1 or x2 is µ2 and x3 is µ3 or x4 is µ4 and x5 is µ5 and x6 is µ6 and x7 is µ7 THEN ysp is µsp. Considering all possible probabilities with C^7_5 (=78125) combination and using our own program called "fuzzy" which is done on C#, we make rules. A huge amount of rules are formed with input parameters and an output crisp. After careful optimization and elimination by our research team, 58 most crucial and appropriate rules are chosen out of 78125 rules so that they can include all possible outputs: Although rules are described in numbers, during the implementation all of them will be turned to linguistic variables. The rule maker software calculates all possible values to our algorithm.

Figure 2. Fuzzy rule maker.

Rule No	Homework	Quiz	Middle Exam	Final Exam	Watched VL	Read E-Book	Virtual CA	Performance
312	65	65	85	85	85	100	100	83.25
313	65	65	85	85	100	100	100	84
314	65	65	85	100	100	100	100	90
315	65	65	100	100	100	100	100	93
316	65	85	85	85	85	85	85	83
317	65	85	85	85	85	85	100	84.5
318	65	85	85	85	85	100	100	85.25
319	65	85	85	85	100	100	100	86
320	65	85	85	100	100	100	100	92
321	65	85	100	100	100	100	100	95
322	65	100	100	100	100	100	100	96.5
323	85	85	85	85	85	85	85	85
324	85	85	85	85	85	85	100	86.5
325	85	85	85	85	85	100	100	87.25
326	85	85	85	85	100	100	100	88
327	85	85	85	100	100	100	100	94
328	85	85	100	100	100	100	100	97
329	85	100	100	100	100	100	100	98.5
330	100	100	100	100	100	100	100	100

1. If (Homework is Very Low) and (Quiz is Very Low) and (Middle Exam is Very Low) and (Final Exam is Very Low) and (Watched Video Lessons is Very Low) and (Read E-Books is Very Low) and (Virtual Class Attendance is Very Low) Then Student Performance is Very Low.

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58. If (Homework is Excellent) and (Quiz is Excellent) and (Middle Exam is Excellent) and (Final Exam is Excellent) and (Watched Video Lessons is Excellent) and (Read E-Books is Excellent) and (Virtual Class Attendance is Excellent) then (Student Performance is Excellent).

8. Implementation of the Student Performance Evaluation System

After having developed theoretical and practical basis, we test our system on simulation tools. For this target we choose Fuzzy Logic Toolbox of MATLAB. Firstly we create a system, secondly determine linguistic variables and make rules after that we can get result and outcomes. The steps are given below as follows:

Figure 3. New Application
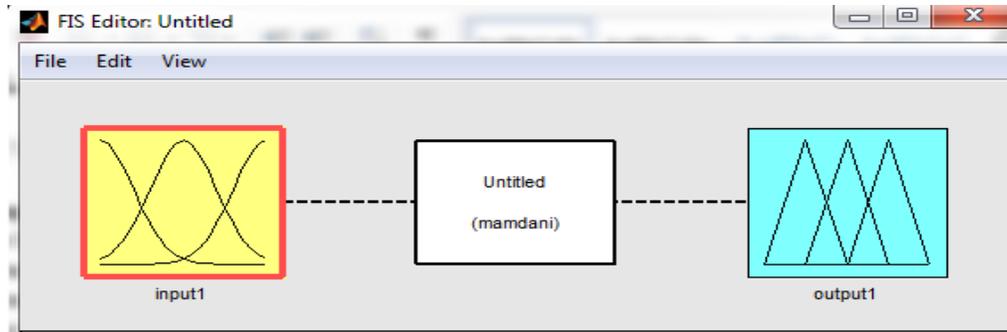
Figure 4. System analysis with input and output crisps (membership functions).
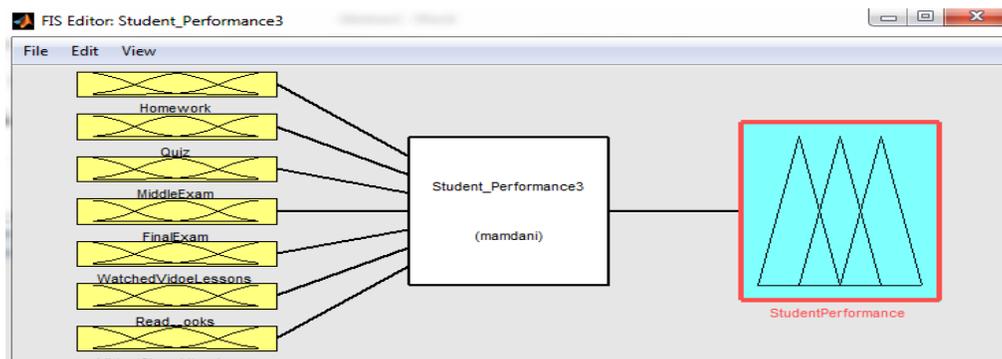
Figure 5 . Membership function "Final Exam"
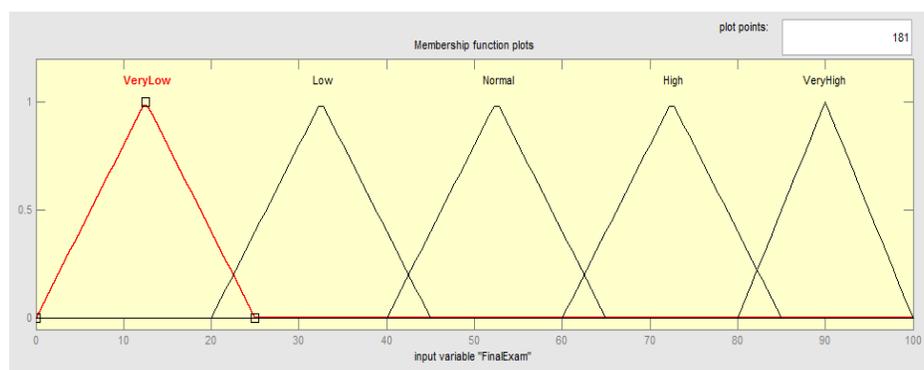
Figure 6 . Membership function "Student Performance"
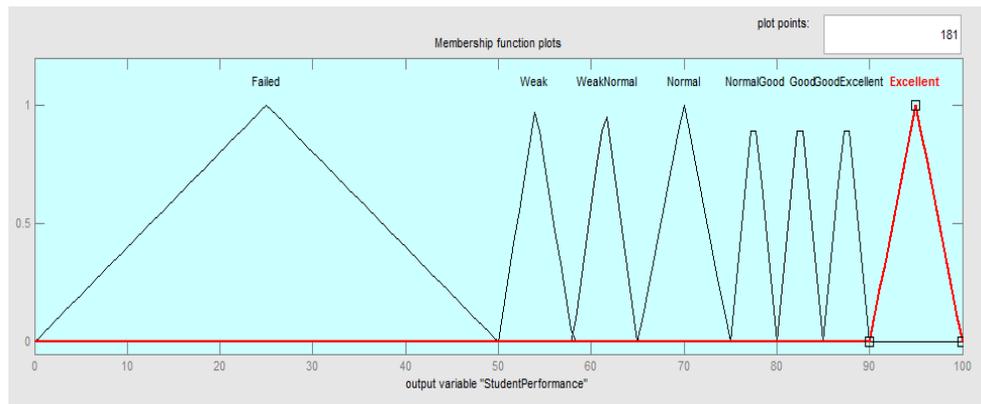
Figure 7. Rules editor
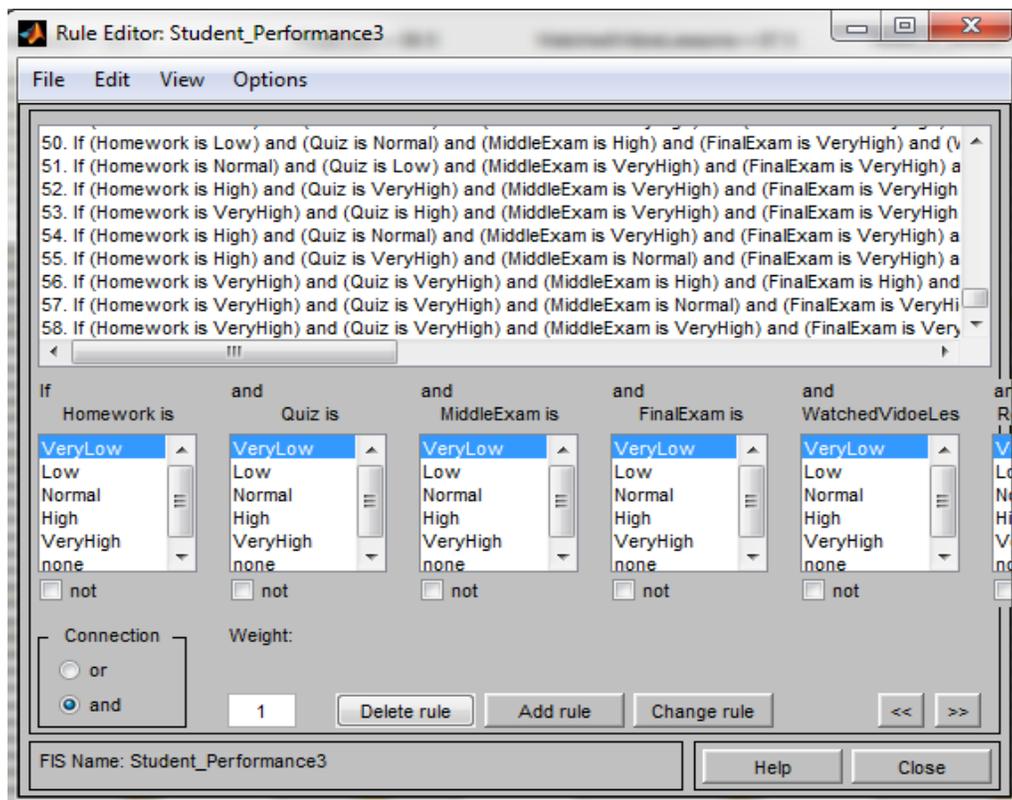
.**Figure 8 .**Performance analysis result.
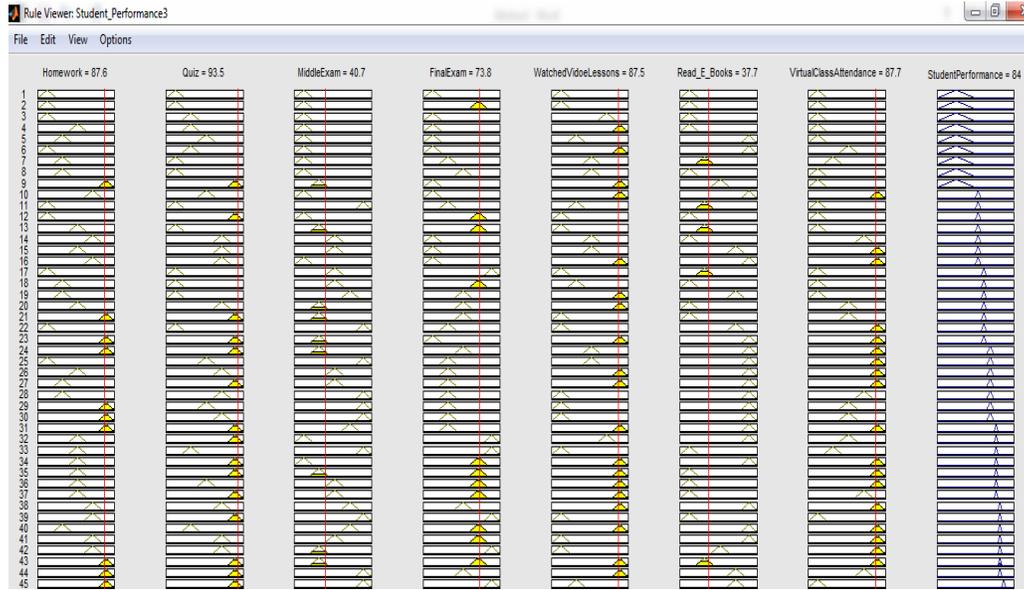
Here we are going to analyse the result over an example: Homework=86.7, Quiz=93.5, Middle Exam=40.7, Final Exam=73.8, Watched Video Lessons=87.5, Read E-Books=37.7, Virtual Class Attendance=87.7 and the result Student Performance=84 is Good. Let's check the rule number 43(If (Homework is VeryHigh) and (Quiz is VeryHigh) and (MiddleExam is Low) and (FinalExam is High) and (WatchedVidoeLessons is VeryHigh) and (Read_E_Books is Low) and (VirtualClassAttendance is VeryHigh) then (StudentPerformance is Good) (1). Comparing the outcome of the calculation and the result of the current rule, we can see that results are the same and we could say that implementation was successful. Additionally, it is flexible to change parameters and rules to be able to get others outcomes and analyse them.

Figure 9 .3-D Surface Viewers.
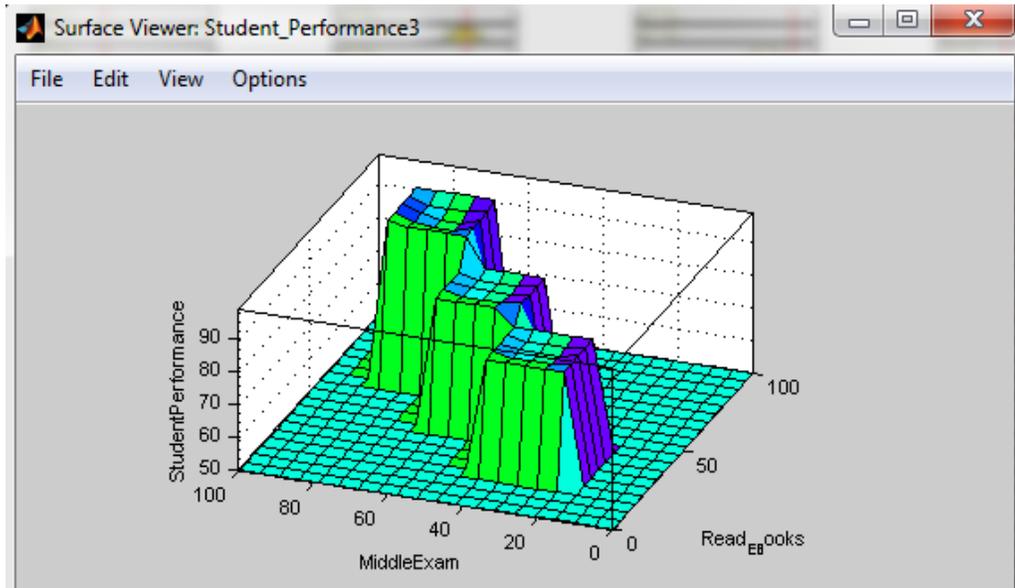
9. Conclusion

To sum up, it appears that many scholars did several research with regards to the measurement of student's performance more specifically in the area of formal (normal) education and limiting to only a few variables (parameters). This left a void which this research addressed. In measuring student performance, we used seven parameters which enhances accuracy, flexibility and credibility as compared to using only limited parameters. The variables used in evaluating students' performance were sufficient and efficient enough to aid students to get the average score. This provides the students with several options to improve on their performance. Fuzzy logic approach was crucial in scaling these variables or parameters to get the desired result of the research. This student evaluating approach is being used by our University. However, this method does have its own limitation because it only caters for single subject. We will attempt to create an approach that can accommodate multiple subjects in the future.

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