FUZZY MODELLING FOR EVALUATION OF MATHEMATICS STUDENTS' MATHEMATICAL SKILL USING MATLAB

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***Abstract:** This paper presents a fuzzy expert system and logic reasoning for evaluation of Mathematics students' Mathematical skill based on fuzzy logic techniques. The attributes which cover the mathematics students' mathematical skill are considered. The suitable fuzzy inference mechanism and associated rule has been discussed. It analyze the principles behind fuzzy logic reasoning and to know how these principles could be applied by educators to evaluating mathematics students' mathematics skill . Some approaches using FIS(fuzzy inference system) have been proposed and the results are compared with traditional method. The modeling and simulation was worked in Matlab-Simulink. The results of simulation proved the validity of proposed technique.*

Keywords: *Fuzzy, Mathematical skill, FIS, Simulink*

I. INTRODUCTION

The emerging trend in science and technology, mathematics are playing a crucial role. Mathematics is the indispensable tool for all curriculums so called as "Queen of science". The programe of mathematics promote the knowledge of mathematical skill and for their intrinsic beauty, effectiveness in developing proficiency in analytical reasoning, and utility in modeling and solving real world problems. In the transformation of a rapidly changing complex, and interdependent society, students have to develop, unceasingly exercise their analytical abilities and to live within and participate with responsibility. Students who have learned to logically question assertions, recognize patterns, and distinguish the essential and irrelevant aspects of problem can think deeply and precisely, share their ideas and nurture the products of their imagination to fruition in reality, insights while seeking and benefiting from the knowledge and insights of the others.

Students majoring in mathematics attain proficiency in cognition skill, problem solving , communication skill. Cognition skill means the psychological result of perception and learning mathematics and reasoning. Problem skill means the ability to identify, reflect upon, evaluate, integrate, and apply different types of information and knowledge to form independent judgments and also critical thinking . (i.e the ability to assess and interpret complex situations, choose among several potentially appropriate mathematical methods of solution persist in the face of difficulty, and present and cogent solutions which includes appropriate justification for their reasoning).

Example: suppose X={5,10,20,30,40,50,60}. A fuzzy set of X may be given by

$A = \{1/5, 1/10, 0.8/20, 0.5/30, 0.2/40, 0.1/50, 0/60\}$.

In this paper we have used the triangular and Communication skill means the ability to communicate and interact effectively with different audiences, and creatively in diverse contexts and developing their ability to collaborate intellectually. Students acquire and enhance these abilities in mathematical contexts, but the acquired habits of rigorous through and creative problem solving are in valuable in all aspect of life. In this paper we evaluate the mathematics students' mathematical skill under knowledge analysis, problem solvingskill and communication skill.

In higher educational institution, evaluation depends on semester examination, test, quizzes, assignment, group project, oral presentation and so on. In recent years, many researchers applied fuzzy logic controller in educational evaluation system. Here we introduce the expert system using fuzzy inference rule for knowledge analysis and Matlab-Simulink model for evaluating overall rating mathematical skill and compared with traditional method. The results of simulation prove the advantage of proposed technique over traditional average techniques. Here, we refer [1-11] the few papers using fuzzy logic and inference rule and a multi-attribute method together for the performance evaluation.

II. FUZZY TOOLS AND TECHNIQUES

A. Fuzzy Set and Membership Function

A fuzzy set A in a universe discourse X is defined as the following set of pairs $A = \{\mu_A(x): x \in X\}$ *or* $A = \{\frac{\mu_A(x)}{x} : x \in X\}$ where A is called the membership function of a fuzzy set A and $\mu_A(x)$ is called the degree of membership value in the fuzzy set A.[12]

trapezoidal membership function for changing the crisp set into fuzzy set. The triangular and trapezoidal membership functions are specified by three parameters (a,b,c) and four parameters (a,b,c,d) respectively as follows:

Triangular(x,a,b,c)= $\max(\min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0)$

Trapezoidal(x,a,b,c,d) = $\max(\min\left(\frac{x-a}{b-a},1,\frac{d-x}{d-c}\right),0)$

Due to their simple formula and computational efficiency, the membership functions have been used performance evaluation.

B. Fuzzy logic

Fuzzy logic theory was introduced by L.A.Zadeh[13]. It is designed for representing knowledge and human reasoning in such a way that it is amenable to processing by a computer. An important concept in fuzzy logic is the application of linguistic variables which are degrees of imprecision. (i.e very bad, bad, average, good, very good). Fuzzy systems implement fuzzy logic, which uses sets and predicates of this kind. Since the classic logic is normally the basic of ordinary expert logic, fuzzy logic is also the basic of fuzzy expert system. In addition to that the fuzzy expert system is dealing with uncertainty and able to model common sense reasoning which is very difficult for general systems.

One of the famous applications of fuzzy logic and fuzzy set theory is Fuzzy inference system (FIS). FIS are knowledge based or rule based systems that contain descriptive if- then rules created from human knowledge and experience. A basic fuzzy architecture consists of three components fuzzifier, FIS, defuzzifier. Fuzzifier works crisp numbers into fuzzy sets whereas the defuzzifier works output set into crisp numbers. This represents the core of fuzzy logic controllers (FLC's); which is built of data-base and rule-base, which constitute the knowledge base and inference engine. A view of basic architecture of fuzzy system is shown in figure 1.

C. Expert system

Set of program of an expert system which manipulates encoded knowledge to solve problem in a specialized domain that normally requires human expertise [14,15]. Expert system knowledge is obtained from expert sources and coded in form suitable for the system to use in its inference or reasoning process. The expert knowledge must be obtained from specialists or other sources of experts, such as texts, journal articles and data base. Expert system differs from conventional computer system has a number of important ways

1. Knowledge is used by the expert system rather than data to control the solution process.
2. The knowledge is maintained and encoded as an entirely separate process which is different from the control solution
3. They are capable of explaining how the conclusion was reached in a particular manner, and why requested information is needed during a conclusion.
4. They use symbolic representations for knowledge (rules, networks or frames) and perform their inference through symbolic computation that closely resembles manipulations of natural language.

D. Designing of fuzzy logic controllers (FLC's)

In this study a stage-wise fuzzy logic reasoning approach[16] has been used for designing of fuzzy inference system(FIS) for the controllers. The stage-wise approach allows for combination of attributes in several stages resulting in elimination of rule explosion problem. A view of stage-wise approach is shown in figure 2. it can be observed from the figure that in stage 1, memory power and cognition skills were combined to give knowledge analysis, independent idea generation and critical thinking were combined to problem solving skill. Similarly in stage 2, knowledge and problem solving skill were combined to mathematical skill which was further combined in stage 3 with communication skill to give overall rating of the student.

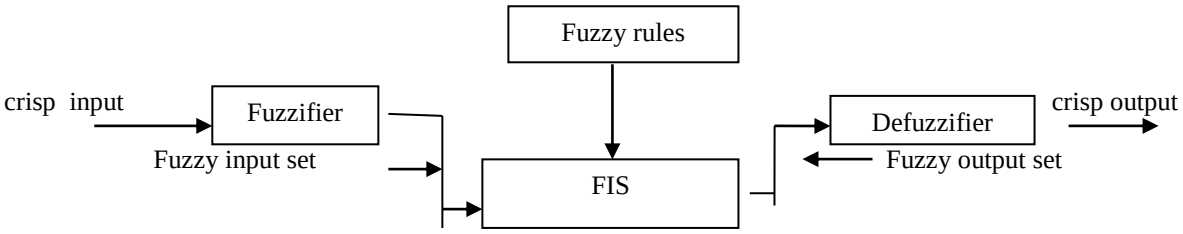


Fig. 1 Basic architecture of fuzzy system

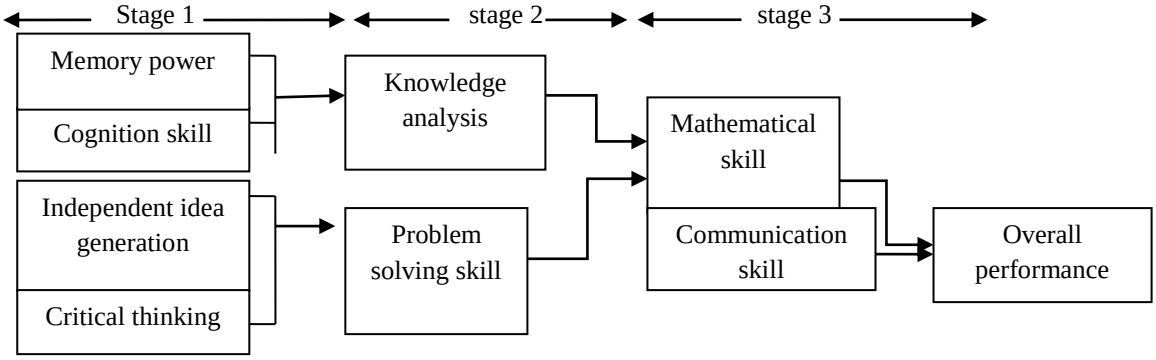


Fig. 2 Stage-wise fuzzy logic reasoning

III. EVALUATION OF KNOWLEDGE ANALYSIS WITH FUZZY EXPERT SYSTEM

Knowledge analysis performance evaluation with fuzzy expert system consist of three steps:

1.Fuzzification of inputs (memory power and cognition skill) and output performance value.

2.Determine the inference rules

3.Defuzzification of performance using matlab.

A. Fuzzification of inputs and outputs

Fuzzification of inputs was carried out using input variables and their membership functions of fuzzy sets. For each student we analyze the memory power and cognition skill as inputs of the fuzzy logic based expert system for analyzing the knowledge skill as a output. The inputs and output have six triangular membership functions which are given in table 1

TABLE 1
FUZZY SET OF INPUT AND OUTPUT VARIABLES

Linguistic variables (input/output)	Interval
Very poor	(0 ,0,20)
Poor	(0,20,40)
Average	(20,40,60)
Good	(40,60,80)
Very good	(60,80,100)
Excellent	(80,100,100)

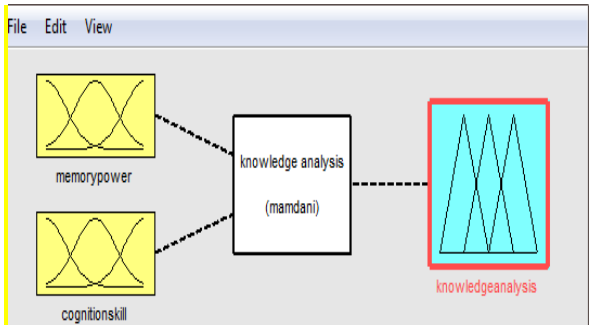


Fig. 3 FIS for knowledge analysis

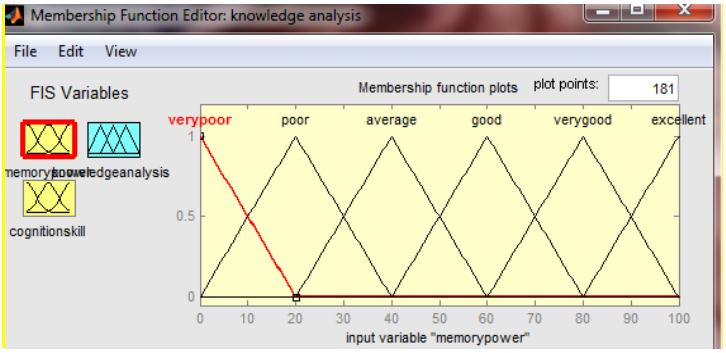


Fig. 4 Membership functions of memorypower

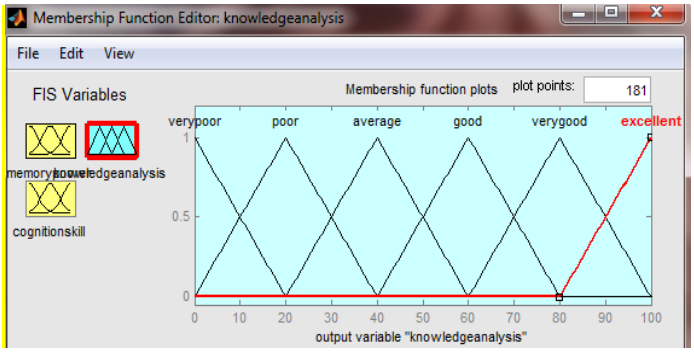


Fig. 5 Membership functions of knowledge analysis

B. Inference Rules

The rules determine input and output membership functions that will be used in inference process. There are 36 if-then rules are determined for knowledge analysis which are given in table 2. The rules were constructed by experts, and vary from one expert to another.

TABLE 2
IF THEN RULES FOR KNOWLEDGE ANALYSIS

Knowledge analysis	Memory power						
Cognition skill		Very poor	Poor	Average	Good	Very good	Excellent
	Very poor	Very poor	Very poor	Poor	Poor	Average	Average
	Poor	Very poor	Poor	Poor	Average	Average	Average
	Average	Poor	Poor	Average	Average	Good	Good
	Good	Poor	Average	Average	Good	Very good	Very good
	Very good	Average	Average	Good	Very good	Very good	Excellent
	Excellent	Average	Average	Good	Very good	Excellent	Excellent

Here, we used the mamdami model .

$$\mu_C(y) = \max_k[\min[\mu_A(input(i), \mu_B(input(j))]], k =$$

$1,2,3,\ldots r.$ (1)

The equation (1) is the output membership function value for each active rule. The 'AND' operator is used between two input values.

C. **Defuzzification of performance**

After completing the decision process , the fuzzy number obtained must be converted to a crisp value. The performance value is calculated using centroid technique. We apply the following formula

$$z = \frac{\int \mu_c(z) x dz}{\int \mu_c(z) dz}$$

IV. EXPERIMENT RESULT

In this paper , proposed fuzzy expert system for students' knowledge analysis evaluation has been implemented in MATLAB. We conducted the test to analyze the memory power and cognition skill of 15 students from II M.Sc Mathematics of R.A. College for women , Thiruvarur. Here, we consider both inputs (memory power and cognition skill) have equal weight on knowledge analysis. Apply the fuzzy expert system for 15 students' marks obtained by memory power and cognition skill. For each student, both input scores were calculated according to rule table, using the mamdami fuzzy decision techniques. The output (performance value) was calculated and then defuzzified by centroid technique of the resulting geometrical shape. The following table shows the knowledge analysis of 12 students.

TABLE 3
INPUT SCORES AND PERFORMANCE VALUE (FUZZY 1)

S.No	Memory power	Cognition skill	Knowledge analysis
1	45	55	45.8
2	30	60	40
3	66	48	55.9
4	22	77	42.7
5	80	75	80
6	83	95	86.2
7	56	40	40
8	38	69	49.2
9	**45**	**35**	**34.3**
10	64	38	44.8
11	92	83	83.8
12	**35**	**45**	**34.3**
13	56	25	35.2
14	84	48	68.4
15	76	72	74.6

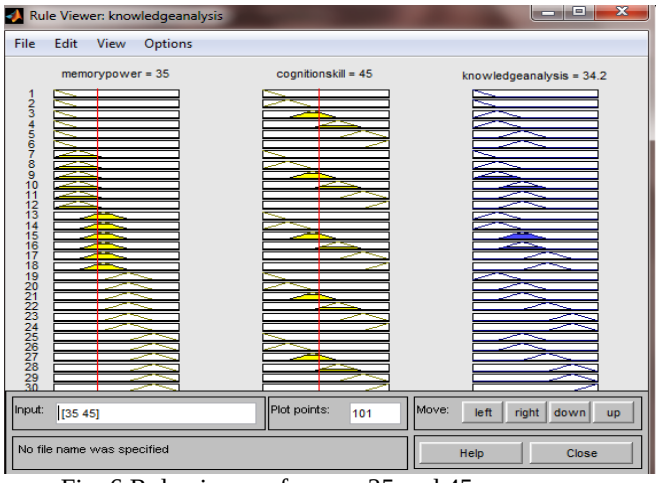


Fig. 6 Rule viewer of scores 35 and 45

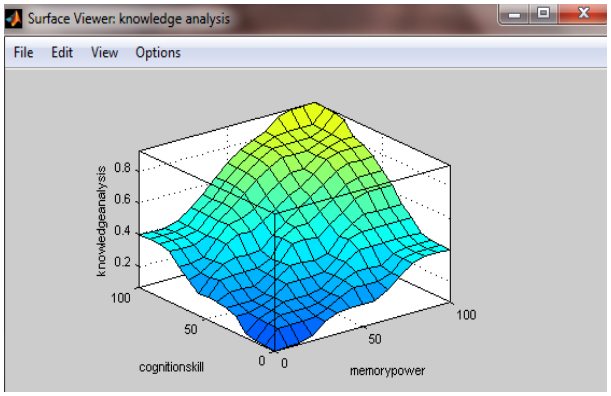


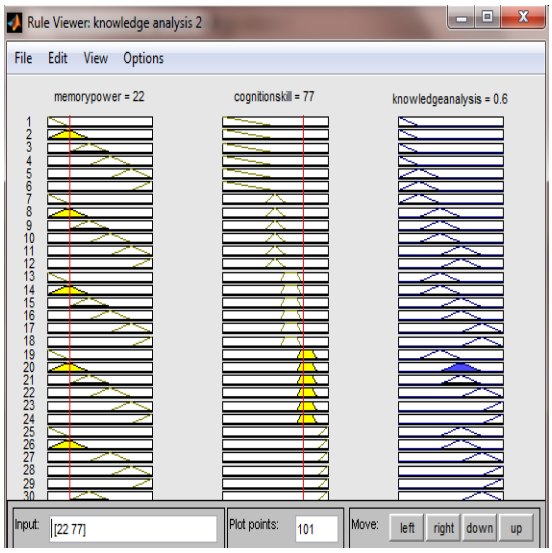
Fig.7 Surface viewer of knowledge analysis performance

Here both inputs are same triangular membership functions. Therefore, the performance value of the inputs (45, 35) and (35, 45) are same. The rule viewer and surface viewer are shown in figure 6 and 7 respectively. If the value of the membership functions is not equal, then cognition skill has more weight on knowledge analysis than the memory power. Let us change the membership function and range for cognition skill , while retaining the original criteria of memory power. So that, the study penalizes the scores below 50 and to reward scores above 50 in cognition skill. This situation can be shown in table :4

TABLE 4
INPUT SCORES AND PERFORMANCE VALUE (FUZZY 2)

S.No.	Memory power	Cognition skill	Knowledge analysis
1	45	55	40
2	30	60	50
3	66	48	45.5
4	22	77	60
5	80	75	80
6	83	95	93.1
7	56	40	8.78
8	38	69	57.3
9	45	35	8.33

10	64	38	8.59
11	92	83	83.8
12	35	45	32.9
13	56	25	7.52
14	84	48	58
15	76	72	76.5



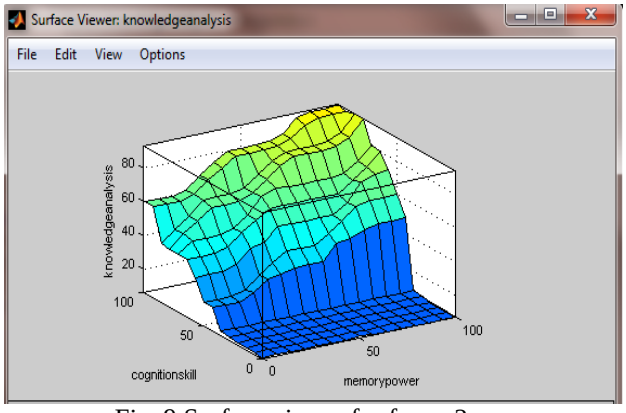


Fig. 9 Surface viewer for fuzzy 2

Fig. 8 Rule viewer for fuzzy 2

V. RESULTS AND COMPARISON

Table 5 shows that comparison between the classical method, fuzzy 1 and fuzzy 2 methods for students' knowledge analysis evaluation . If a student successful in the classical method , they will also be successful in the fuzzy 1 method. Comparison of the classical method to fuzzy 2 scenario gives differences in the performance values. For scores below 50, the performance value of fuzzy 2 is smaller than the classical method and for above 50, the performance value of fuzzy 2 is larger than the classical method. The graph represented the linear relationship between fuzzy 1 and classical method which is shown I figure 10..

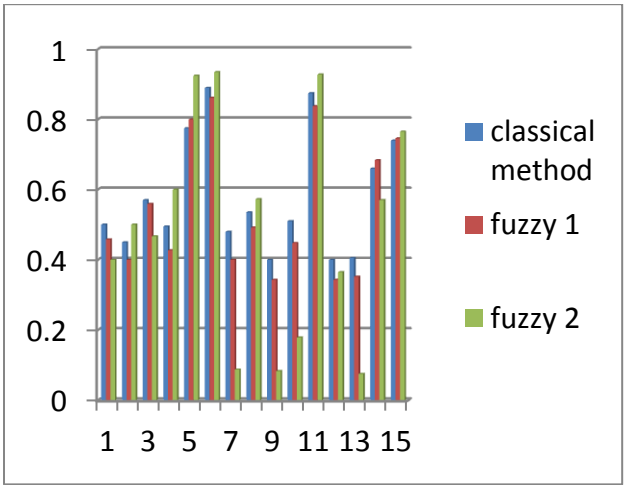


Fig. 10 comparison of classical method, fuzzy 1 and fuzzy 2 for knowledge analysis

TABLE 5
COMPARISON OF EVALUATION METHODS

S.No	Memory power	Cognition skill	Knowledge analysis (classical method)	Knowledge analysis Fuzzy 1	Knowledge analysis Fuzzy 2
1	45	55	50	45.8	40
2	30	60	45	40	50
3	66	48	57	55.9	45.5
4	22	77	49.5	42.7	60
5	80	75	77.5	80	80
6	83	95	89	86.2	93.1
7	56	40	48	40	8.78
8	38	69	53.5	49.2	57.3
9	45	35	40	**34.3**	8.33
10	64	38	51	44.8	8.59

11	92	83	87.5	83.8	83.8
12	35	45	40	**34.3**	32.9
13	56	25	40.5	35.2	7.52
14	84	48	66	68.4	58
15	76	72	74	74.6	76.5

VI. EVALUATION OF OVERALL PERFORMANCE USING FUZZY LOGIC CONTROLLER

A mamdani type FIS with expert system (fuzzy 2) has been used for knowledge controller which is shown in figure2.1. There are 36 if-then rules are constructed for other controllers. If –then rules for problem solving skill are shown below.

TABLE 6
IF THEN RULES FOR PROBLEM SOLVING SKILL

Problem solving skill	Critical thinking						
Independent idea generation		Very poor	Poor	Average	Good	Very good	Excellent
	Very poor	Very poor	Poor	Poor	Poor	Average	Average
	Poor	Poor	Poor	Poor	Average	Average	Good
	Average	Poor	Poor	Average	Good	Good	Very good
	Good	Poor	Average	Good	Good	Very good	Very good
	Very good	Average	Average	Good	Very good	Very good	Excellent
	Excellent	Average	Good	Very good	Very good	Excellent	Excellent

In similay way, the rules for other controllers were designed. For evaluating overall performance, we considered the input variables for every controller as attributes. The attributes were represented by alphabetic symbols was shown below. The value of each attribute was taken out of 100.

TABLE 7
SYMBOL FOR EACH ATTRIBUTE

Attribute	Symbol
Memory power	A
Cognition skill	B
Independent idea generation	C
Critical thinking	D
Communication skill	E

Evaluation of overall performance using fuzzy logic controller were given below and compared with traditional method. From the result, we know about the importance of the fuzzy expert system. Here, we presented the result of overall performance of 6 trials using different values of attributes.

Trial: 1

TABLE 8
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
40	30	50	45	40	29.47	41

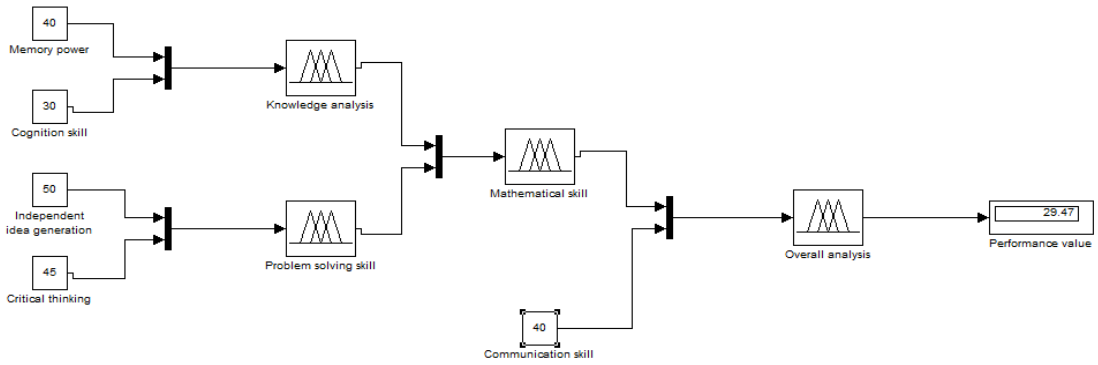
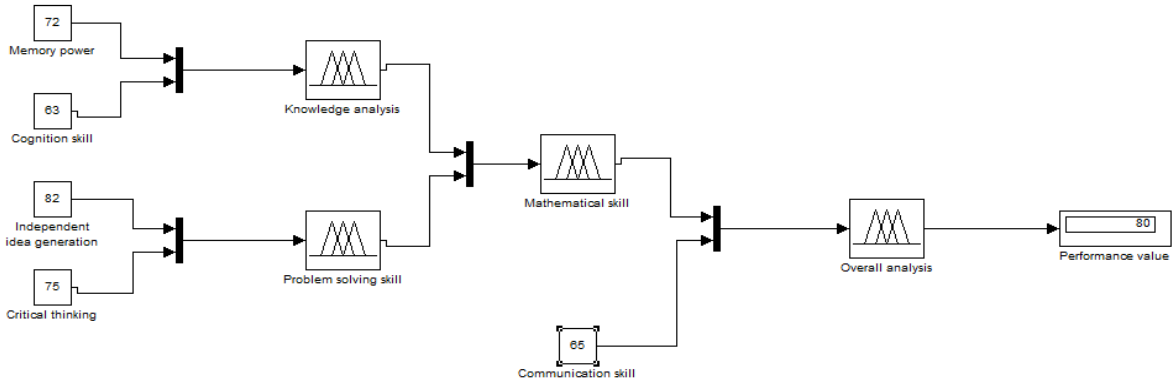


Fig. 11 Simulation of FLC's

Trial: 2

TABLE 9
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
72	63	82	75	65	80	70.4



Figur.12 simulation of FLC's

Trial: 3

TABLE 10
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
80	67	73	70	30	52.75	64

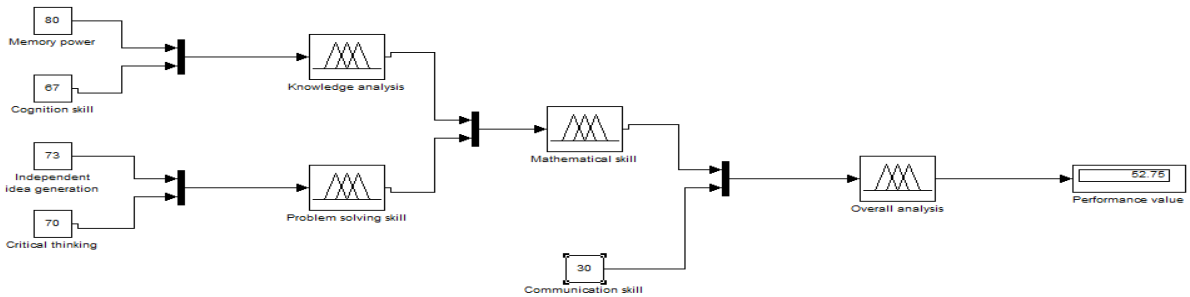


Fig.13 Simulation of FLC's

Trial: 4

TABLE11
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
50	32	40	44	60	40	45.2

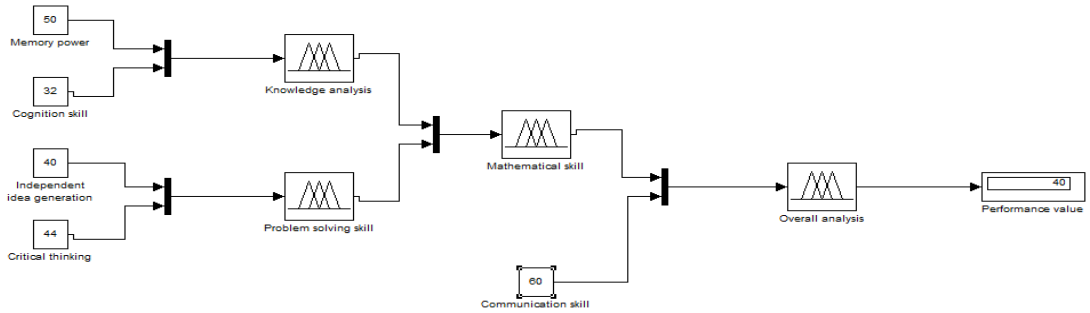


Fig.14 Simulation of FLC's

Trial: 5

TABLE 12
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
70	92	83	87	75	80.01	81.4

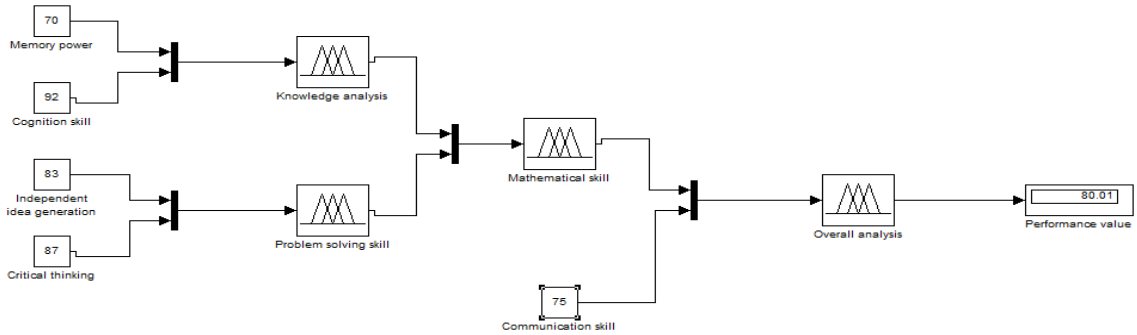


Fig. 15 Simulation of FLC's

Trial: 6

TABLE 13
RESULTS COMPARISON

A	B	C	D	E	Fuzzy performance value	Average value
83	95	82	90	87	81.33	87.4

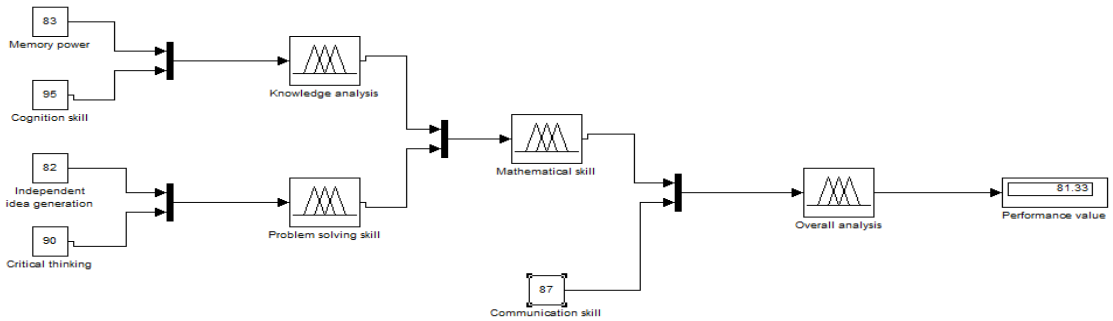


Fig.16 Simulation of FLC's

VII. CONCLUSION

In this paper, we have discussed the new method for performance of students' mathematical skill using logic techniques, denoted as fuzzy expert system. The results are evaluated from fuzzy expert system, there was a difference between the classical method and fuzzy expert system. In fuzzy-1,all membership functions were same for both memory power and cognition skill, whereas in fuzzy- 2, membership functions of cognition skill were modified. The advantage of fuzzy expert system was proved , using fuzzy logic controller in Matlab-

Simulink. In this study cognition skill was given more importance than memory power for evaluating knowledge analysis. Independent idea generation, critical thinking were given equal importance for problem solving skill. Mathematical skill had more importance than the communication skill for evaluating overall performance. Therefore, for a very low cognition skill the overall performance value using traditional method is 41 which is very large as compared to fuzzy approach i.e. 29.47(refer table). The attributes B, C, D have more values than A and E, then the fuzzy performance value is higher than the average value(refer table). It also observed that both of the result fuzzy method and average method are more or less same. From this methodology, we pick the correct person who have more mathematical skill. The proposed model can be modified and used for performance evaluation of employees, faculty, and select the person from the campus interview etc.

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