Fuzzy Logic based Assessment Model Proposal for Online Problem-based Learning

Abdulkadir Karacı
Kastamonu University
Faculty of Engineering and Architecture, Turkey

ABSTRACT
In this research, problem based learning over web is suggested. This model includes fuzzy logic and MYCIN trust factor. Through the model, MYCIN trust factor and the number of attempts to solve the problem are used in order to identify students' learning levels. MYCIN confidence factor value and number of attempts to solve the problem are to be entered to fuzzy logic decision system. The output of the fuzzy logic decision system becomes the new level of learning. This level of learning is calculated through fuzzy logic in linguistic term as well as numeric expression. In every try, a hint given to student. Each used hint lowers the score of the student. Thus the students who solved the problem in one try will score more than the ones who solved the problem in more than one try.

Keywords
Online Problem-Based Learning, Fuzy Logic, MYCIN Trust Factor

1. INTRODUCTION
Problem-based approaches to learning have a long history of advocating experience-based education. One of the important methods of constructivist approach is problem-based learning (PBL) approach. Psychological research and theory suggests that by having students learn through the experience of solving problems, they can learn both content and thinking strategies. PBL is an instructional method in which students learn through facilitated problem solving [1, 2].

Problem based learning draws on essentially constructivist principles of learning, advocating learner centered engagement with course materials and content as well as learner interaction with peers as central to the process associated with learning how to practice theoretical knowledge to professional contexts [2]. The main principle of PBL is based on maximizing learning with investigation, explanation, and resolution by starting from real and meaningful problems. Therefore, PBL is the art of problem solving [3].

Today, problem-based learning is becoming more widespread all around the world. For instance, 80 percent of the medical faculties in the US use problem-based learning approach [2]. Although the literature contains many studies about face to face problem-based learning [1, 4-9], there is quite a limited number of studies on online problem-based learning [2, 6].

In many disciplines, problem-based learning creates a more positive effect on the attitudes of students towards lessons in comparison to the traditional method [10].

The description of knowledge can be quite obscure or uncertain, or it can even contain considerable uncertainty. There are many mathematical theories for expressing uncertainty and which could be used to deal with the uncertainty in the description of the user knowledge. One of these methods is the certainty factor, and the other is fuzzy logic. One of the first techniques used to solve the uncertainty problem in the description of knowledge is factor of certainty. This technique was developed as an expert system called MYCIN to overcome the uncertainty [11-13].

This study proposes a fuzzy logic-based assessment model for online problem-based learning. According to the proposed model, the student solves the problems determined by the teacher online. The MYCIN confidence factor is calculated based on the student solution. When the student solves the problem correctly, the confidence factor score and the number of attempts to solve the problem enter the fuzzy logic decision system. As an output, new MYCIN score and the linguistic expression of learning level are obtained. If the problems to be solved have not finished yet, such score is used as the CFP parameter in the calculation of the MYCIN score in the following problem. If the problems to be solved have come to an end, such score becomes the learning level score of the student. The linguistic expression of this score is regarded as the linguistic expression of learning level. The fuzzy sets employed in this study, the algorithmic structure of the proposed assessment method, and the mathematical model used for calculating the MYCIN score are explained in detail in the Method section below.

2. METHODOLOGY
According to the model proposed in this study, the student solves the problems determined by the teacher online. If the student solves the problem incorrectly, a clue is given him/her, and s/he is asked to solve the problem again. As a parameter, the teacher determines the maximum number of attempts to solve the problem. If this parameter has not been determined by the teacher, the student can try as many times as the number of clues given. If the student solves the problem incorrectly and s/he does not have any more chance to try, the MYCIN score is calculated by assuming that the student has solved the problem incorrectly. Such calculated score does not enter the fuzzy logic decision system as the problem has been solved incorrectly. It is used as the CF_P parameter in the calculation of the MYCIN score in the following problem.

When the student solves the problem correctly, the MYCIN confidence factor score is calculated again. This confidence factor score calculated and the number of attempts to solve the problem enter the fuzzy logic decision system. The output of the fuzzy logic decision system is the new MYCIN score. Such new MYCIN score is used as the CFP parameter in the calculation of the MYCIN score in the following problem. A student solving the problem in one attempt does not have the same MYCIN score as a student solving it in more attempts. When the student solves all problems, the output of the fuzzy logic decision system is the learning level of the student. That is, the MYCIN confidence factor score and the number of attempts to solve the problem are used for determining the learning level of the student. The student is considered successful if s/he achieves the learning level determined by the teacher. Otherwise, s/he is asked to solve all problems again. In addition, the fuzzy logic decision system indicates the learning level linguistically as follows: Definitely Does Not Know, Might Know, Most Probably Knows.

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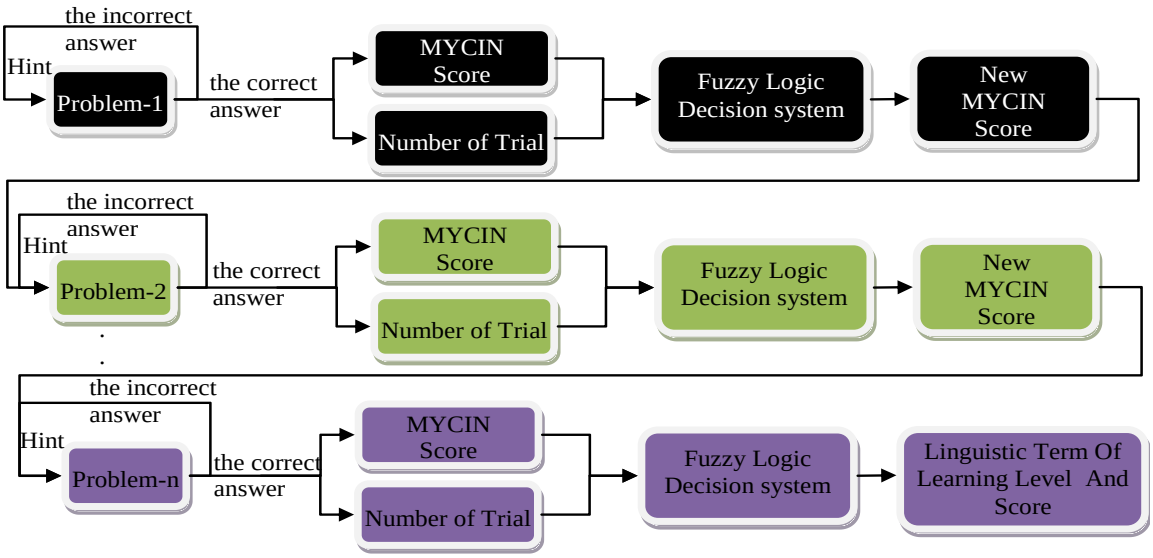

Fig 1: The structure of the proposed model

2.1. MYCIN Confidence Factor

MYCIN is an expert system developed by a group of specialist physicians led by Edward Feingbaum in the University of Stanford in 1976. In this system, confidence factor is estimated to eliminate uncertainty and to reach a conclusion using the data in the system [14]. For any subject, the Confidence factor (CF) takes a value between -1 and 1. If CF is close to -1, it indicates that a student has not grasped a subject; if it is close to 1, it means he or she has grasped. When the CF value is close to 0, it shows that there is little information about whether a student knows the subject or not [15, 16]. In the calculation of student scores according to the MYCIN confidence factor, the mathematical model in sources [15-17] was used.

$CF_{New}=CF_p+CF_q- CF_p* CF_q$, IF CF_p and $CF_q>=0$; (1)

$CF_{New}=CF_p+CF_q+ CF_p* CF_q$, IF CF_p and $CF_q<0$; (2)

$CF_{New}=(CF_p+CF_q)/(1-MIN(|CF_p|,|CF_q|))$, Else. (3)

CF_{New}: The new confidence factor after the student answers a question.

CF_p: The confidence factor obtained from the previous questions answered by the question.

CF_q: The confidence factor belonging to the question answered by the student.

CF_q is determined as indicated in the equation 4 and the equation 5.

$CF_q= CF_c$, if the question has been answered correctly (4)

$CF_q= -CF_{ic}$, if the question has been answered incorrectly (5)

2.2. Fuzzy Logic Decision System Input-Output Variables and Fuzzy Sets

Fuzzy logic was developed as a mathematical model by Zadeh in 1965 to represent uncertainty [18]. As can be seen in Fig. 1, the fuzzy logic system used to determine new MYCIN Score or Learning Level has two inputs: MYCIN Score and Number of Trial. As can be seen in Fig. 2, for MYCIN score and Learning Level, 7 fuzzy sets were defined with π membership function, and as can be seen in Fig. 3, for the Number of Trial (number of attempts to solve the problem), 5 fuzzy sets were defined with π membership function. π membership function is defined as follows [19].

$$\pi(x,b,c)=\begin{Bmatrix} S(x;c-b,c-\frac{b}{2},c) \\ 1-S(x;c,c+\frac{b}{2},c+b) \end{Bmatrix} \quad (6)$$

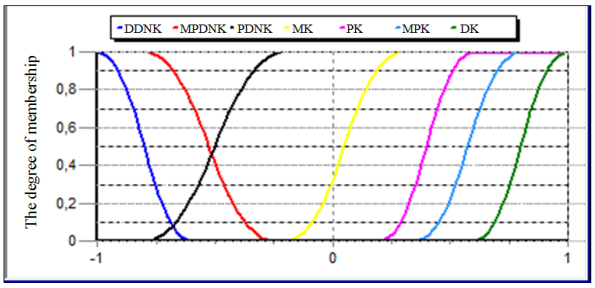

Fig 2: The fuzzy for input variable MYCIN Score (MS) and output variable Learning Level

Table I. The fuzzy sets and limit values for input variable MYCIN Score (MS) and output variable Learning Level

Fuzzy Set	Limits
DDNK (Definitely Does Not Know)	-1<=MS<=-0,6
MPDNK(Most Probably Does Not Know)	-0,8<=MS<=-0,25
PDNK (Probably Does Not Know)	-0,8<=MS<=-0,2
MK (Might Know)	-0,2<=MS<=0,3
PK (Probably Knows)	0,2<=MS<=0,6
MPK (Most Probably Knows)	0,35<=MS<=0,8
DK (Definitely Knows)	0,6<=MS<=1

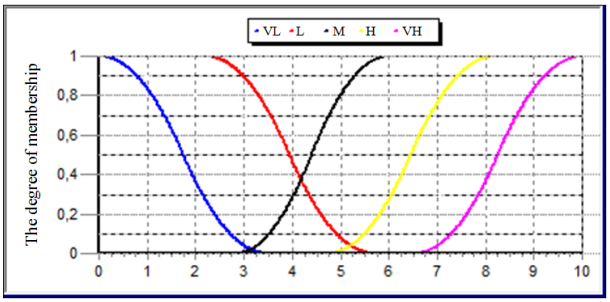

Fig 3: The fuzzy sets for input variable Number of Trial

Table II. The fuzzy sets and limit values for input variable Number of Trial(NT)

Fuzzy Set	Limits
VL (Very Low)	0<=NT<=3
L(Low)	3<=NT<=5
M (Moderate)	3<=NT<=6
H(High)	5<=NT<=8
VH (Very High)	7<=NT<=10

The membership functions and their rule bases were determined after several tests and experiments. The rule base used in fuzzy logic decision system is shown in Fig. 4.

NT \ MS	DDNK	MPDNK	PDNK	MK	PK	MPK	DK
VL	DDNK	MPDNK	PDNK	PDNK	MK	PK	DK
L	DDNK	MPDNK	PDNK	PDNK	MK	PK	MPK
M	DDNK	MPDNK	MPDNK	PDNK	MK	MK	PK
H	DDNK	DDNK	MPDNK	MPDNK	PDNK	PDNK	MK
VH	DDNK	DDNK	MPDNK	DDNK	MPDNK	MPDNK	PDNK

Fig 4: The rule base used in fuzzy logic decision system

The Larsen Method was used in fuzzy logic decision system as the implication function. The Larsen method is defined as follows [20].

$$R_p = A \times B = \int_{u \times v} \mu_A(u)\mu_B(v)/(u,v) \quad (7)$$

"The Weighted Average" method was implemented as the defuzzification method. Being a highly effective and efficient calculation method, this is a frequently used defuzzification method in fuzzy logic applications. The weighted average method is described as follows [21].

$$x^* = \sum \mu_c(\chi)\chi / \sum \mu_c(\chi) \quad (8)$$

x^*: Defuzzied value

χ :The output of each membership function

3. RESULTS AND DISCUSSION

In this study, the fuzzy logic decision system employed in the proposed model is experimentally tested by assigning some MYCIN score values and number of attempts to solve the problem to the system. The MYCIN score, which is the output of the fuzzy logic decision system, the linguistic expression of the learning level, and input values are indicated in table 3.

Table III. Experimental study on the fuzzy logic decision system

App. Code	Input: Number of Attempts	Linguistic Term	Input: MYCIN Score	Linguistic Term	Output: New MYCIN Score	Output: New Linguistic Term
A	1	VL	0,7	MPK	0,64	MPK
	3	L			0,62	MPK
	6	M			0,23	MK
	8	H			-0,29	PDNK
	10	VH			-0,72	MPDNK
B	1	VL	0,9	DK	0,8	MPK
	3	L			0,79	MPK
	6	M			0,53	PK
	8	H			0,16	MK
	10	VH			-0,2	PDNK

As is seen in the table 3 and figure 5, new MYCIN score (i.e. learning level score) decreases as the number of attempts to solve the problem increases. For example, in the case A, while the student solving the problem in 1 attempt reaches the learning level of 0.7 (MPK), the student solving the same problem in 6 attempts reaches the learning level of 0.23 (MK), and the student solving the same problem in 10 attempts reaches the learning level of -0.72 (MPDNK).

In the case B, while the student solving the problem in 1 attempt or 3 attempts reaches the learning level of 0.9 (MPK), the student solving the same problem in 6 attempts reaches the learning level of 0.53 (PK), the student solving the same problem in 8 attempts reaches the learning level of 0.16 (MK), and the student solving the same problem in 10 attempts reaches the learning level of -0.2 (PDNK).

The results of these two cases and the figure 5 demonstrate that the fuzzy logic decision system works properly.

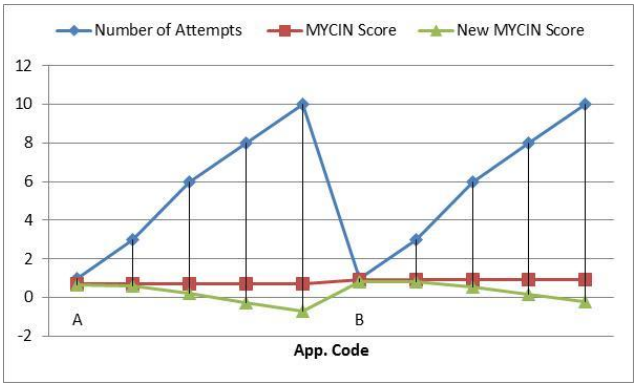

Fig 5: The experimental study on the fuzzy logic decision system

4. CONCLUSIONS

According to the proposed model, the MYCIN score is used for determining the learning level. However, this level is not determined by using only the MYCIN score. If the learning level is determined only by looking at the MYCIN score, "Definitely Knows" or a close value are obtained for each problem. This is because; the student will correct his/her

mistakes as s/he receives clues, and thus s/he will solve the problem correctly. That will not reflect the truth. Thus, the number of attempts in which the student solves the problem is used while calculating the learning level as per the proposed model. In this way, a difference occurs between the learning levels of the student who solves the problem correctly in one attempt and the student solving the problem correctly in more attempts.

The output of the fuzzy logic decision system is both numerical and linguistic expression (MK, MPK, DK, etc.) of the learning level. By this means, at what level the student has learnt a subject is expressed to him/her linguistically, thereby leading to a more meaningful situation.

The next study will develop a web-based version of the model proposed in this study, and will test the system at higher education level.

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