

Fuzzy Logic and Computer Programming Academic Achievement of Students: Attitude as Input Variable

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Abstract

Students' participation and performance in academic activities is fast reducing; however, the purpose of this study is to investigate the effects of students' attitudes towards the computer programming classes and computer teacher on the students' programming achievements. In this research, fuzzy logic is used. The participants of this study were 44. An attitude inventory was used to measure the participants' attitudes towards the lesson and teacher. Students' academic success levels were determined using participants' grades at the end of first semester. Scores obtained from the attitude inventory were categorized by the experts. Finally, by using fuzzy logic modeling in MATLAB, the cases in which the minimum and maximum achievement level occurs were determined. The attitudes towards the lesson and the teacher have been assumed as an input and the success as for output factor. Using fuzzy logic between the input and the output factors, a model was generated. The aim of this model is to state the relation the input and the output factors and to have an idea about the success on mathematical education. It was found that just one positive attitude towards the lesson or the teacher cannot be seen as been enough for success when examined the obtained grade. It was concluded that if there is not a high positive attitude to teacher and the computer programming, an advanced level success is not observed or vice versa. It was recommended that should be positive attitude for both the teacher and the lesson for achievement.

Keywords: fuzzy logic, academic achievement, attitude

Introduction

Computer programming is one of the most popular occupations in these days. There is Computer Programming topic/course in the curriculum of computer science in the universities. These programs firstly have been founded as formal and evening education and they have continued their education and teaching activities. The main objective of computer programming programs is to prepare programmers having the technical knowledge and experience to be able to use information technologies and accommodate with the improving technologies. It is expected from the computer programming candidates to be graduated from this program to have computer programming skill at upper level. Computer programming skill requires having some kind of thinking skill such as logical thinking and problem solving (Korkmaz, 2012).

The goal of learning is to benefit from knowledge. In the current Nigeria educational system, learning is evaluated through acquiring subject knowledge that is reflected by grades. In Nigeria, Computer Programming is an obligatory course that Computer students need to take during their university study. Computer programming is mostly perceived as a difficult course by the students (Başer, 2013). From first year to final year, most Computer students are afraid of taking Programming course.

There are lots of factors affecting students' success in Computer Programming. Researchers indicated that these factors include but not limited to math talent, personal and family factors, parents' level of education, active participation in Computer Programming classes and the sufficiency of Computer Lecturers teachers teaching Computer Programming classes (Savaş, Taş & Duru, 2010). Two other factors affecting students' Computer Programming success are emotions and attitudes toward

Computer Programming. Emotions and attitudes are intertwined in a way that attitudes towards any person, object or situation can result in emotions toward it. Both attitudes and emotions such as liking or disliking are among important factors that effect Computer Programming success in a class is crucial to be successful in it. So, attitudes guide learning and there is a significant relationship between attitudes towards Computer Programming success (Yenilmez, 2010). In other words, one of the important reasons of math failure is the negative attitudes toward the Computer Programming.

The fact that computer programming is perceived as a difficult course results in the fact that they develop mostly negative attitudes regarding programming (Başer, 2013). Negative attitude regarding programming has a negative effect on the success of students. Hence, the studies finding out that such factors as negative perception, motivation and especially low level of attitude can make negative effect on learning computer programming take the attention (Korkmaz & Altun, 2013). This negative attitude had contributed to students poor academic achievement in Computer programming and solve this problem, student academic performance could be optimized using fuzzy logic model.

Fuzzy Logic is a super set that promotes flexible reasoning which is an extension of the Boolean logic by Lofti Zadeh (1965) from the mathematical theory of fuzzy sets[1]. Fuzzy logic is an extension of the classical set theory. It was proposed by Prof. Lofti Zadeh in the year 1965. It is mostly used to deal with imprecision and vagueness of human subjective judgment and represent information from zero to one (Menakshi and

Nagar, 2015). The feature of flexible reasoning accommodates all inaccuracies and uncertainties and it has an advantage of setting its rules in natural language. This means that it handles the concept of in-between values or truth - i.e values in between completely truth and completely false.

The theory of fuzzy sets is the foundation of fuzzy logic and a generalization of the classical set theory. In other words, the classical set theory is a subset of the fuzzy set theory (Behbahan, Azari, and Bahadori, 2013).

Human reasoning most times are approximate in nature especially when common sense is used, that is why fuzzy logic is important to solve the problems of “inconclusive conclusions” (Behbahan, Azari, and Bahadori, 2013).

Membership Function: Membership function is an important function in the application of fuzzy logic and the representation of the fuzzy logic performance (Sadollah, 2018). It is the foundation blocks of the fuzzy set theory and thus aids in representing a fuzzy set. The shape of a membership function is dependent on the problem that is being solved (Sadollah, 2018).

L.A. Zadeh developed fuzzy logic modeling (FLM) in 1965 (Zadeh, 1965). Classical logic is not sufficient to explain lots of problems in real life. With fuzzy logic in addition to wrong or right responses, a “partly true” response is emerged. There is no certainty in explaining indefiniteness by using linguistic factors. FLM is a quite successful method in indefinite situations. Fuzzy logic has been considered for many theoretical studies (Grezegorzewski & Winiarska, 2014). It is also used for the solution of practical application. Initially, it was used in the control panel of steam machines

(Mamdani, 1974). Later on, it was used in many engineering studies (Sugeno & Takagi 1983). Currently, it is used in order to solve many real-life problems not only engineering and fundamental sciences but also social sciences (Akday et al. 2016). It is in the light of the above, this study is conceived to optimize student academic performance in Computer Programming.

Methodology

Data Collection

Data for this study was collected from Department of Computer Science and Computer Education in the 2019 -2020 academic calendar educational year. 44 students comprising of 20 females and 24 males participated in the study. Inputs of this study are attitudes towards the teacher and attitudes towards the lesson. To evaluate the students' attitudes, an attitude scale was applied to the participants after obtaining approval from the Heads of Department. Output of the study is the academic achievement. To measure academic achievement, computer programming grades of the students were used.

Fuzzy Logic Approach

According to the classical logic approach, an element either belongs to a set or not, that can be explained by using characteristic function χ_A of a set A as the following:

$$\chi_A = \begin{cases} 1, & \text{if } x \in A \\ 0, & \text{if } x \notin A. \end{cases}$$

On the other hand, according to fuzzy logic, a member may belong to multiple clusters. Therefore, sometimes we need fuzzy logic to describe some of the real-life problems better introducing partial membership.

As mentioned above, fuzzy logic modeling starts with the concept of a fuzzy set. A fuzzy set is a set without a crisp and clearly defined boundary. Assume X is an ordinary set, whose elements are denoted by x . Membership in an ordinary subset A of X can be expressed by the characteristic function, μ_A from X to $\{0,1\}$ as follows:

Definition 1: If X is a collection of objects denoted by x , then a fuzzy set A in X is a set of ordered pairs

$$A = \{(x, \mu_A(x)) : x \in X\}$$

where $\mu_A(x)$ is a membership function and it takes values between 0 and 1.

Definition 2: (Convex Fuzzy set) A fuzzy subset A of X is called convex if the following inequality holds:

$$\mu_A(\lambda x_1 + (1 - \lambda)x_2) \geq \mu_A(x_1) \wedge \mu_A(x_2) \quad \forall x_1, x_2 \in X, \lambda \in [0,1].$$

Definition 3 : Let A be a fuzzy subset of X ; the support of A , denoted $\text{supp}(A)$, is the crisp subset of X whose elements all have nonzero membership grades in A , $\text{supp}(A) = \{x \in X | \mu_A(x) > 0\}$.

Definition 4: h –cut of a set A is closed interval and membership degree provides the following feature:

$$A_\alpha = \{x: \mu_A(x) > \alpha\}$$

If $\{x: \mu_A(x) \geq h\}$ is closed μ_A is upper semi-continuous.

Definition 5 : Let A and B are fuzzy subsets of a classical set X . We say that A is a subset of B if $A(t) \leq B(t), \forall t \in X$.

Definition 6: If the degrees of at least member of fuzzy set are 1, the set is normal fuzzy set. There is an x for which $\mu_A(x) = 1$, if the set is not normal, the following statement $\frac{\mu_A(x)}{\max \mu_A(x)}$ are used to normalize.

Definition 7: [Grezegorzewski, Winiarska, 2014] A fuzzy set A is called a fuzzy number if the following properties hold:

- is normal,
- is fuzzy convex, i.e.

$$\mu_A(\lambda x_1 + (1 - \lambda)x_2) \geq \mu_A(x_1) \wedge \mu_A(x_2) \quad \forall x_1, x_2 \in \mathbb{R}, \lambda \in [0, 1]$$

$\square \mu_A$ is upper semi-continuous,

• $\text{supp}(A)$ is bounded, where $\text{supp}(A) = \text{cl}(\{x \in X: \mu_A(x) > 0\})$ and cl is the closure operator.

Definition 8: The core of a fuzzy number A is the set of all points that surely belong to A , i.e.,

$$\text{Core}(A) = \{x \in \mathbb{R}: \mu_A(x) = 1\},$$

Now, we define some operations in fuzzy sets;

Definition 9: Intersection: the membership function of the intersection of two fuzzy sets A and B is defined as:

$$\mu_{A \cap B}(x) = \min(\mu_A(x), \mu_B(x)), \forall x \in X$$

Definition 10: Union: the membership function of the union is defined as:

$$\mu_{A \cup B}(x) = \max(\mu_A(x), \mu_B(x)), \forall x \in X$$

Definition 11: Complement: the membership function of the complement is defined as: $\mu_{\bar{A}}(x) = 1 - \mu_A(x), x \in X$

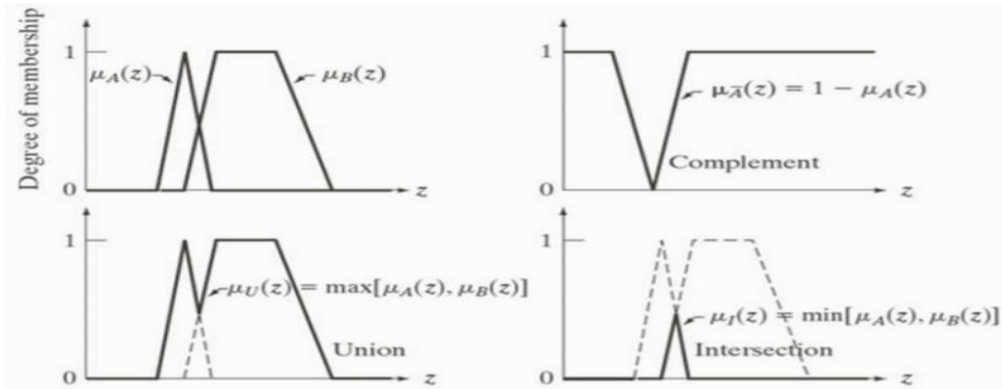


Figure 1: Operations on fuzzy sets.

When research studies regarding the application fuzzy logic were examined, the results indicates that two types of Fuzzy Inference Systems (FIS) namely Mamdani and Takagi-Sugeno are common in the literature. It has been argued that, each of these FIS

outmaneuvers each other from time to time but there is no conclusive evidence showing superiority of one of them. Although, both of these systems have membership for input, the output for them is different. In comparison to Mamdani system that has membership for output. In Sugeno systems, the output membership function is polynomial that consists of coefficient and input. Although, it is easy to create Mamdani system; for Sugeno system calculation is easy. In Mamdani system, defuzzification is made to results. In comparison to Mamdani system that has a set of fuzzy sets as output, Sugeno system consists of a fixed or linear output.

Mamdani systems consist of 3 parts. These parts are:

Fuzzification – convert the classical data or crisp data into fuzzy data or Membership Functions (MFs)

Fuzzy Inference Process – combine membership functions with the control rules to derive the fuzzy output

Defuzzification – use different methods to calculate each associated output and put them into a table: the lookup table. Picks up the output from the lookup table based on the current input during an application.

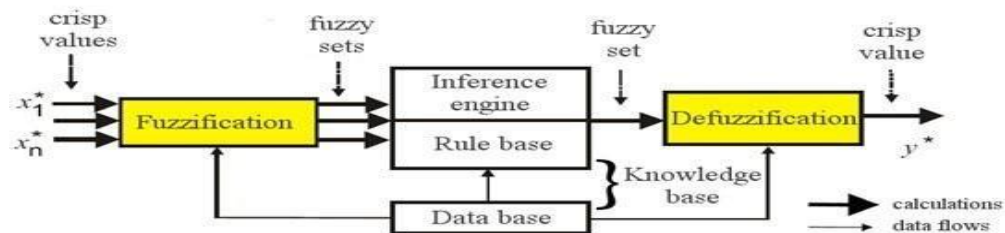


Figure 2: Fuzzy system.

In the fuzzification stage, the crisp values become fuzzy values and the membership functions are defined for the inputs and outputs. Among different kinds of membership functions such as triangular, trapezoidal, Z-shaped, Gaussian, sigmoidal, S-shaped whose graphs are shown in Fig. 3 we use triangular and trapezoidal membership functions defined as the following:

Triangular fuzzy number (TFM): The membership function of a TFM $\mu_A(x)$ has the following form:

$$\mu_A(x) = \begin{cases} 0, & x < a_1, \\ \frac{x-a_1}{a_2-a_1}, & a_1 < x < a_2, \\ \frac{a_3-x}{a_3-a_2}, & a_2 < x < a_3, \\ 0, & x > a_3. \end{cases}$$

where $a_1, a_2, a_3 \in R$ and $(x, \mu_A(x)) \in A$.

Trapezoidal fuzzy number (TRFM): The membership function of a TRFM $\mu_A(x)$ has the following form:

$$\mu_A(x) = \begin{cases} 0, & x < a_1, \\ \frac{x-a_1}{a_2-a_1}, & a_1 < x < a_2, \\ 1, & a_2 < x < a_3, \\ \frac{a_4-x}{a_4-a_3}, & a_3 < x < a_4, \\ 0, & x > a_4. \end{cases}$$

where $a_1, a_2, a_3, a_4 \in R$ and $(x, \mu_A(x)) \in A$.

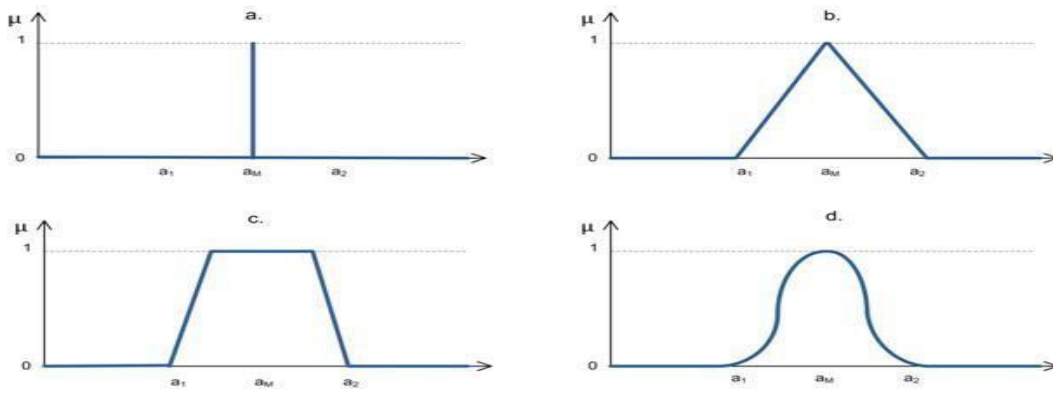


Figure 3: The membership functions.

For the inference engine, the linguistic rules „if ...then... „ which are commands of the system behavior are set up. These rules determine the relations between inputs and outputs. Accordingly, it takes minimum values for inputs fuzzy sets.

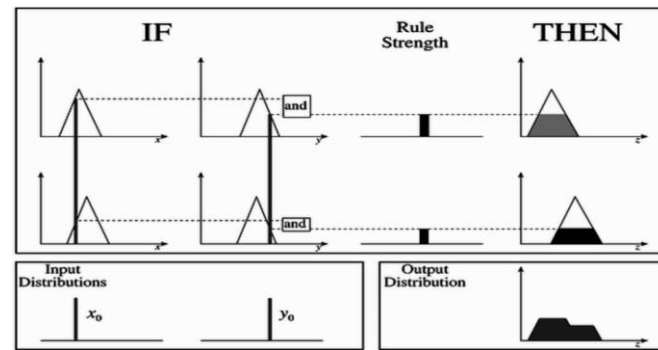


Figure 4: Inference engine.

Later the value obtained by the union of the fuzzy output set is found. At the last stage in defuzzification, fuzzy values are transformed into crisp values. At this stage we have fuzzy sets for output but we need crisp numbers instead. So we will use defuzzification. There are different types of defuzzification methods such as: centroid, bisector, middle of maximum (MOM), smallest of maximum (SOM), and largest of maximum (LOM).

We prefer to use centroid technique in this study. Centroid of gravity method returns the output by calculating the centroid of area formed by the aggregated fuzzy sets of the consequents.

Results

The parameters Attitude Towards Teacher (ATT) and Attitude Towards Lesson (ATL) effect the Academic Achievement (AA). As a result of application of attitude scales to the students and correspond the computer programming grades of students, the data collection is obtained. The obtained data collection is presented in Table 1.

Table 1: Data Collected

No	ATL	ATT	AA
1	30	78	50
2	29	88	86
3	62	83	71
4	54	59	95
5	46	98	78
6	25	79	52
7	28	82	57
8	38	96	60
9	46	82	82
10	22	72	58
11	44	90	75
12	64	72	65
13	33	86	54
14	39	90	27
15	33	87	53
16	51	71	31
17	41	89	34
18	91	93	93
19	76	93	87
20	62	89	85
21	82	86	66
22	41	75	30

23	61	91	75
24	54	75	44
25	32	84	25
26	55	85	51
27	41	60	31
28	83	94	58
29	33	79	30
30	54	92	65
31	67	93	28
32	44	78	40
33	61	83	26
34	32	71	50
35	22	71	38
36	87	99	68
37	50	94	43
38	54	87	45
39	56	57	20
40	64	86	40
41	58	90	53
42	45	75	43
43	23	57	42
44	51	55	30

To set up a model, we build a fuzzy logic model whose input variables are ATT and ATL and the output variable is AA (academic achievement). The general structure of the model is shown in Fig. 5.

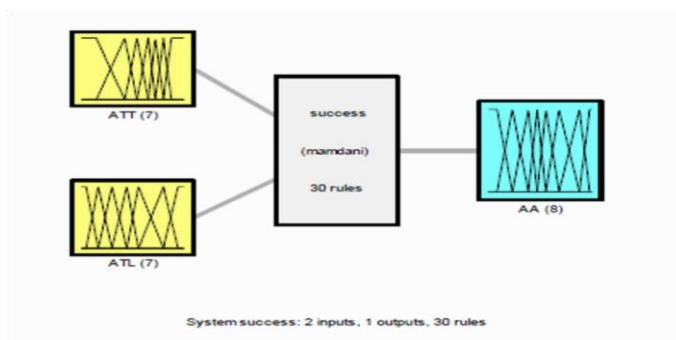


Figure 5: System success: 2 inputs, 1 outputs, 30 rules

Fuzzy logic shows experience and preference through its membership functions. Scores that can be obtained from ATT are classified into seven categories. The scores between 50 and 71 are categorized as 1, the scores between 57 and 77 are categorized as 2, the scores between 71 and 82.5 are categorized as 3, the scores between 77 and 86 are categorized as 4, the scores between 82.5 and 90 are categorized as 5, the scores between 86 and 94 are categorized as 6 and the scores between 90 and 100 are categorized as 7. The results are shown in Fig. 6:

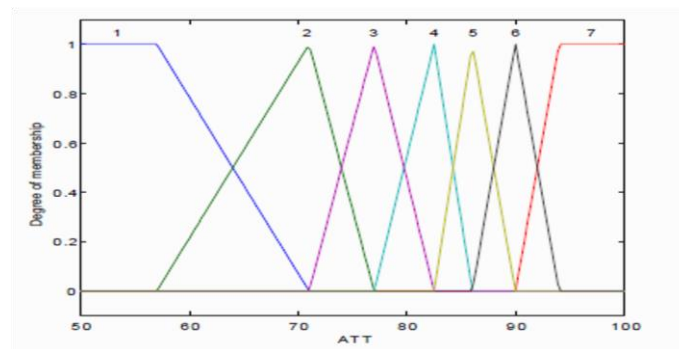


Figure 6: ATT (Attitude Towards the Teacher)

ATL are also classified into seven categories. The scores between 20 and 32 are categorized as 1, the scores between 23 and 42 are categorized as 2, the scores between 32 and 53 are categorized as 3, the scores between 42 and 61.5 are categorized as 4, the scores between 53 and 80 are categorized as 5, the scores between 61.5 and 91 are categorized as 6 and the scores between 80 and 95 are categorized as 7. These categories were mathematically modeled by fuzzy sets, as shown in Fig. 7:

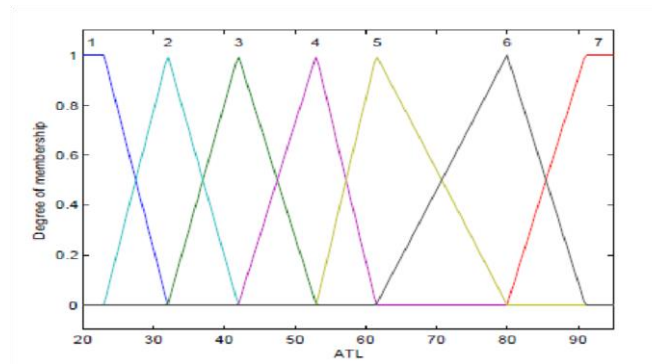


Figure 7: ATL (Attitude Towards the Lesson)

The output of academic achievements are classified into eight categories. The scores between 25 and 41 are categorized as 1, the scores between 30.5 and 52 are categorized as 2, the scores between 41 and 58 are categorized as 3, the scores between 52 and 64 are categorized as 4, the scores between 58 and 73 are categorized as 5, the scores between 64 and 87 are categorized as 6, the scores between 73 and 94 are categorized as 7 and the scores between 87 and 95 are categorized as 8,. These categories are mathematically modeled by fuzzy sets, as shown in Fig. 8:

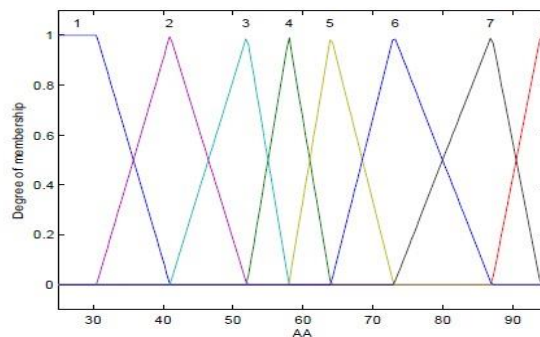


Figure 8: AA (Academic Achievement)

The rule structure of the model is designed based on how the experts interpret the characteristics of the variables of the system. It is possible to write down a lot of if-

then statements. Fuzzy rules and some of the rules used in the model are as the following:

If ATT is 2 and ATL is 2 then AA is 3

If ATT is 2 and ATL is 1 then AA is 2

If ATT is 3 and ATL is 3 then AA is 2

If ATT is 1 and ATL is 1 then AA is 2

If ATT is 1 and ATL is 4 then AA is 1

If ATT is 3 and ATL is 3 then AA is 1

If ATT is 6 and ATL is 4 then AA is 5

The correlation coefficient R^2 obtained using regression analysis shows that the experimental results and fuzzy logic results for the academic achievement are close to each other at the rate of 94%. It is shown in Fig. 10.

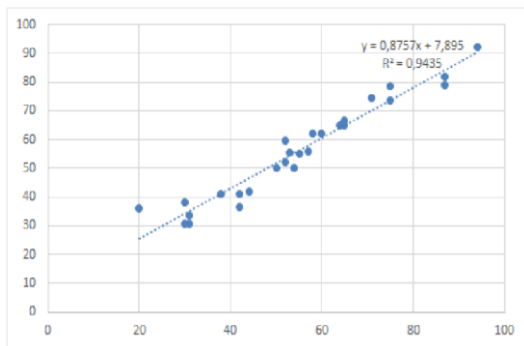


Figure 10: The correlation coefficient

Discussion

In this study fuzzy logic has been used and the effect of students' attitude toward both the teacher and the computer programming has been analyzed by means of attitude scales. The data is composed by measuring the level of the attitude towards the teachers and the lesson, by considering the averages of grades at the end of the first term as

academic success. The attitudes towards the lesson and the teacher have been assumed as an input and the success as for output factor. By using fuzzy logic between the input and the output factors, a model has been generated. The aim of this model is to state the relation the input and the output factors and to have an idea about the success on mathematical education. We deduce that just one positive attitude towards the lesson or the teacher can not been seen enough for success when examined the obtained grade. We also conclude that if there is not a high positive attitude to teacher and the computer programming, an advanced level success is not observed or vice versa. There should be positive attitude for both the teacher and the lesson for achievement. When there is negative attitude toward them, there will be low success. After forming, the output data has been obtained by being entered input factors. When analyzed the real values and fuzzy logic model values, it is observed that there is a close relation between real values and fuzzy logic model values. 94% correlation coefficient is found when compared real value and system value by being taken into consideration fuzzy logic model. The high level academic success can be acquired with interest for both the teacher and the lesson.

Conclusion and Recommendation

For further study; since there are many factors affecting the learning by changing input factors, any other studies can be conducted. Some different modeling techniques can be practiced for this kinds of problems and the comparison of these modeling techniques can be searched. Furthermore, proposed method can be effective in terms of precision and credibility of results for large data sets.

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