

LEARNING PREFERENCE ASSESSMENT: A FUZZY LOGIC APPROACH

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ABSTRACT

Learning Preference Assessment is necessary to assess the students' readiness to be involved in the self-directed learning such as online learning. Knowing the level of Learning Preference Assessment, an educational institution or students can prepare themselves to be better to get involved in the online learning. The measurement of Learning Preference Assessment that has been done so far is by using the questionnaire of Learning Preference Assessment in which the score of total score of each questionnaire is classified into the level of students' Learning Preference Assessment. Every level has certain score range. The total number of students in each level used the statistical principle and classical logic but they still have a weakness since they do not consider the total score of the certain level threshold. As a consequence, the mapping of the level of students' Learning Preference Assessment in the university or study program results in inaccuracy. We propose a fuzzy method that is a mathematical approach and human's cognitive aspect in this level measurement. The research results showed that there was a difference of the score of Learning Preference Assessment between using the statistical method and using the fuzzy logic method. The Fuzzy system can find the different level that cannot be found by statistical or logical analysis.

Keywords: *Online learning, Self Directed Learning, Learning Preference Assessment, Statistical, Fuzzy Logic*

1. INTRODUCTION

Online learning has developed dynamically over the world to provide many opportunities for independent study and collaboration with the unlimited space and time [18]. Online learning can involve any educational institutions such as university and many students from many areas in the certain learning network. In online learning, the technical skill of students is significant, but the research showed that the readiness to do self-directed learning or the skill to manage the learning by themselves is more important [15]. The individual's knowledge and attitude even give the good basis to study independently. Besides the knowledge, attitude, and skill, the positive habit building can reinforce the success of the online learning approach [16]. If the students are definitely ready to take online learning, the use of online learning will be efficient, effective and

economical [12]. On the contrary, if the students are not ready to be included in the online learning, the learning process will be unstructured and take a long time and the last it will cause the students frustrated in learning. The benefit of self-directed learning readiness is to encourage the motivation and self-control since the students are expected can learn without an instructor. Most of the literature (for example, [3], [6], [7]) agree with [12] stating that considering the students' readiness is an essential factor to conduct online learning.

One of the ways to avoid the effect of student's unreadiness in learning is the online learning provider should do an initial evaluation and prepare the students to be involved in online learning. Survey of the level of students' readiness to study independently should be conducted to develop the online learning in some universities or areas so that it can ease to map the goodness and

weakness of the students in each university so that the university can provide certain intervention for the online learning readiness. The measurement of the level of self-directed learning readiness to be involved in online learning is better using Self-Directed Learning [31];[13];[4].

In measuring the self-directed learning, the instrument mostly used is Self-Directed Learning Readiness Scale or it is called Learning Preference Assessment (LPA) developed by Guglielmino, [13]. LPA is used to measure not only the self-directed learning readiness but also the personal characteristics of the candidate of online learning user [31]. The LPA measurement done so far is by using LPA questionnaire [14] in which the total score of the mark of each questionnaire is classified into the students' LPA level. Every LPA level has the certain score range. The recap of the number of students in each LPA level used the principle of statistic and classical logic. These principles are highly used [10];[26];[11], but they still have some weaknesses because they do not consider the total score of the threshold of the certain LPA level. As the result, the mapping of LPA level in the educational institution like a university or in the level of study program is inaccurate.

We recommend a new method namely fuzzy method which is a mathematical approach and the human's cognitive aspect [2]. The statements such as disagree, agree, strongly agree, and the other typical statements are the cognitive aspects that can be measured by using the fuzzy method. Therefore, this study tried to apply the principle of fuzzy logic to determine the LPA level. The fuzzy logic method has been frequently used in the learning system. The learning systems analyzed by using this fuzzy method are: measurement of student's learning performance [42];[41];[1];[35];[22];[29], concept mapping [20];[21];[30];[33], self-regulated learning [38], measurement of learning motivation [34], remedial learning system [5];[19];[25], collaboration learning [17];[18]. All those studies used the cause and effect system (If ... Then ...) showing the need for input and output variables. This research did not need the output variable but it mapped the level by using the fuzzy method. The focus of this research was developing a simple method that is easily applied in the learning preference assessment that can evaluate the student and university to be ready to be involved in the online learning system. The primary statement in this research is whether there is a difference of LPA

result analysis between using Statistic and using Fuzzy methods we recommend.

2. LITERATURE REVIEW

2.1. Learning Preference Assessment (LPA)

LPA is a quantitative instrument that is mostly used for Self-Directed Learning [27]. This instrument has been translated into 20 languages and utilized in the research in more than 40 countries. This instrument was developed by Guglielmino, [14] to measure the complexity of attitude, skill and ability, and characteristic of readiness to be involved in the independent study (Self-directed learning). LPA has 58 items of Likert scale statements [14] and the respondents are requested to read the statements and then show how far the statements describe the attitude, faith, behavior, or the skill.

Some tests of the reliability level of these items were done and all the reliability coefficients were in the range of 0.72-0.96. The tests found that LPA is an accurate instrument and it is beneficial to measure the self-directed learning readiness [27]. The LPA level is shown in the following Table 1 by Guglielmino:

Table 1: Learning Preference Assessment Level

Score of LPA	LPA Level
58-188	Low
189-203	Below average
204-218	Average
219 -232	Above average
233-290	High

The individual's LPA level can be increased by a treatment or certain practice. According to Guglielmino [14], he/she with the high LPA level prefers to determine his/her learning needs, plan, and conduct the learning by him/herself. It does not mean that he/she will not choose to be in a structured learning condition. The individual's with the average LPA level possibly gets success in the more independent situation, but he/she does not totally enjoy all processes of learning need identification, planning, and his/her learning implementation. The individual's with the LPA level which is below the average usually tends to like the structured learning such as delivering a speech and the regulation of the traditional class. The research study has proven that the self-directed learning can be improved through the intervention of proper education [27]

2.1 Theory of Fuzzy Logic

Fuzzy Logic was firstly delivered by Zadeh [43]. The variable of fuzzy uses the membership function to describe the mapping from input to the proper membership. The membership function operates in the range of [0,1]. The Fuzzy approach was applied broadly in the modeling. For example, it is developed in the artificial intelligence system and expert system [28], and the modeling of any characteristics of students such as the student's knowledge level of a certain subject [24]. This case is because the Fuzzy Logic has the problem-solving skill that is higher than the theory of standard probability [41]. Generally, Fuzzy Logic can measure the imprecise score and place it on the proper level [42]. Two principal things of fuzzy becoming the reference in this research are the fuzzy set and membership function.

One fuzzy set A in a universe set X is defined as a pair of the set as follow:

$$A = \{(\mu_A(x) : x \in X)\} \tag{1}$$

where $\mu_A(x) : X \rightarrow [0,1]$ is a mapping called membership function of fuzzy set A and $\mu_A(x)$ is called membership score or degree of $x \in X$ in the fuzzy set A. In other words, it is written as follow:

$$A = \{(\mu_A(x) / x : x \in X)\} \tag{2}$$

Example: suppose $X = \{6, 2, 0, 4\}$. A fuzzy set X can be given by $A = \{0.2 / 6, 1/2, 0.8 / 0, 0.1 / 4\}$.

In this paper, we use the membership function of the trapezoid to convert the crisp score into the fuzzy set. A trapezoid is defined by the bottom border a, upper border d, where $a < b < c < d$ as shown in Figure 1. There are two special cases of the trapezoidal function called R-function and L-function: R-function: with the parameter of $a = b = -\infty$ (figure 1b), L-Function: with the parameter of $c = d = +\infty$ (figure 1c).

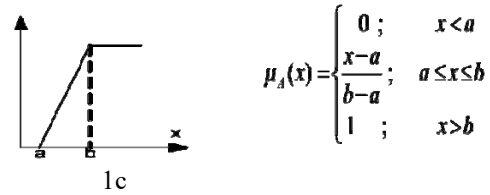
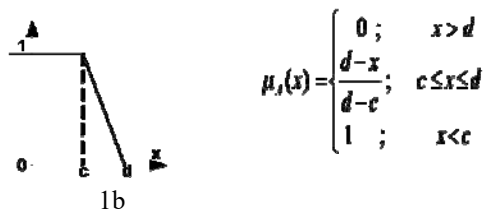
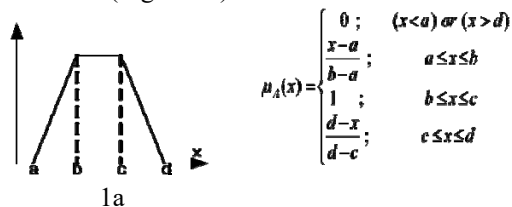


Figure 1: Trapezoidal Membership Function

3. METHODS

3.1. Design

The Fuzzy Logic approach was used to measure the student's LPA level aiming at determining the more accurate level. The significant thing to show is the purpose of this recommended method is not to change the traditional method in the evaluation but to strengthen this system by giving additional information that will be used for decision making by the user. Figure 2 shows the analysis method proposed for LPA.

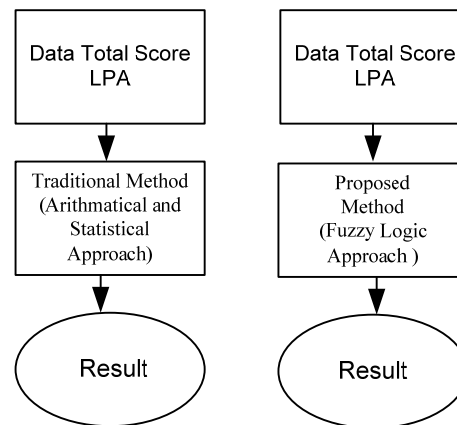


Figure 2: Comparison of Measurement of LPA Level

The architecture of Fuzzy Logic System proposed for Learning preference assessment (LPA) are as follow:

1. **Crisp Score:** the Crisp score is the score obtained in LPA.
2. **Fuzzification:** fuzzification of the crisp score (student's score) is changed into the input score of Fuzzy used by the appropriate membership function (trapezoidal membership function).
3. **Fuzzy Output:** determining the output of membership function

Defuzzification (LPA): Defuzzification means calculating the final score (LPA score) by using the appropriate defuzzification method. In this work, we have used the method of Centre of Ares (COA) for Defuzzification.

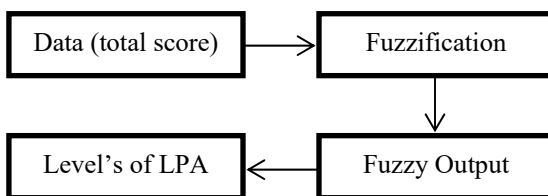


Figure 3: The Steps of Fuzzy System to Determine the Level of Learning Preference Assessment

3.2. Participants

The research was conducted in five Study Programs of Computer Field in Kupang city, East Nusa Tenggara, Indonesia where the online learning system is rarely used. For this study, the participants were 84 students consisting of ten students of Diploma Program in Informatics Engineering, Computer Science Academy, 15 students from Undergraduate Program in Informatics Engineering, Computer Science Academy, 11 students of Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang, and 24 students were from Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang. Their ages are around 18 and 20 years old ($M= 18.78$, $SD= 0.653$).

3.3. Instrument

This research used questionnaire having 58 items of statements with the Likert scale type [14] to measure the self-directed learning readiness or Learning Preference Assessment. It is a self-report instrument that was developed by Guglielmino, [13] to measure the complex of attitudes, abilities, and characteristics that comprise readiness to engage in self-directed learning.

The adult form of the questionnaire (*SDLRS-A* or *Learning Preference Assessment*) has 58 items [14]. Respondents are asked to read a statement and then indicate the degree to which that statement accurately describes their own attitudes, beliefs, actions or skills. a split-half Pearson product moment correlation with a Spearman-Brown correction produced a reliability coefficient of 0.94. Most published studies on populations over twenty years old report similar reliability figures that fall within a range of 0.72 - 0.96. Score is a measured of current level of LPA/Self-Directed Learning Readiness [27];[37].

3.4. Procedure

The first step was determining the participant by random selection of the students coming from each study program in the computer field in Kupang City, East Nusa Tenggara Province, Indonesia. Subsequently, the research participants filled the questionnaire. Based on the questionnaire data, the participants' LPA level was analyzed by using the following two analysis methods:

1. Statistical method: Determination of the participants' LPA level was based on the obtained total score, and every total score of the students was classified into LPA level based on Table 1.
2. Fuzzy Logic method: determination of participants' LPA Level was determined based on the fuzzy score that transferred every total score into the appropriate membership function by using trapezoidal membership function (figure 1). The total score of fuzzy of each LPA level was calculated by using fuzzification method of Center of Area (CoA).

4. RESULTS

4.1. LPA Level Determination Based on Statistical Method

Based on the obtained data of the questionnaire, the total scores were calculated and classified to the appropriate LPA level. For example, if the student' total score is 222, he/she is the "above average" LPA level based on table 1. The descriptive statistic was used to describe the average score and standard deviation of each LPA level for all study programs in the computer field. These results were analyzed and are presented in Table 2.

We found that averagely, two students in Study Program of Computer Science in Kupang City were in the "high" LPA level with the standard deviation of 1. The number of students who had the "low" LPA level in each study program of computer field in Kupang was fewer than the other LPA levels. When we explored each group, we found the similar number of students in some LPA levels. For instance, Diploma Program in Informatics Engineering, Computer Science Academy and Undergraduate Program of Informatics Engineering, Computer Science Academy had the same total number of students with the "low" LPA level which was one person. Similar to both groups, Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang and Diploma Program in

Computer and Network Engineering, State Polytechnic of Kupang did not have the students with the “low” LPA level.

Table 2: Learning Preference Assessment Based on Statistical Method

High	Level LPA				Total
	Above Average	Average	Below Average	Low	
2	1	5	1	1	10
1	5	5	3	1	15
3	6	9	4	2	24
3	4	3	1	0	11
1	8	5	10	0	24
10	24	27	19	4	84
2	4.8	5.4	3.8	0.8	
1	2.59	2.19	3.70	0.84	

Study Program
Diploma Program in Informatics Engineering, Computer Science Academy
Undergraduate Program of Informatics Engineering, Computer Science Academy
Undergraduate Program of Information System, Computer Science Academy
Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang
Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang
Total
M
SD

The student classification in each LPA level used the rule of classical logic (crisp logic):

$$Y = \begin{cases} 1; & \text{if total score} = \text{level of LPA's score} \\ 0; & \text{another level of LPA's score} \end{cases}$$

If student X has a total score of 190, it means that the student gives the score of 1 in the level of “below the average”, and 0 to the other LPA levels. To see the weakness of this approach, we can see the following explanation.

If the student has a score of 232, it means that the student gives a score of 1 in the level of “above the average”, and 0 to the other levels. Whereas, 232 is very close to the score of 233 that is in the “high” LPA level. Therefore, it is reasonable if we regard the score of 232 in both LPA levels namely

the level of “above average” and “high”. We used a fuzzy based system that uses not only 0 but also the other scores between 0 and 1. It means that the student has the membership degree in the level of “above average” and “high.” The next step of this fuzzy based analysis system is presented in the next section.

4.2. Determining the LPA Level Based on Fuzzy Logic Method

The trapezoidal membership function of Fuzzy for each LPA level used the membership function like the Figure 1 so that it resulted in the membership function for the research as follow (Figure 4):

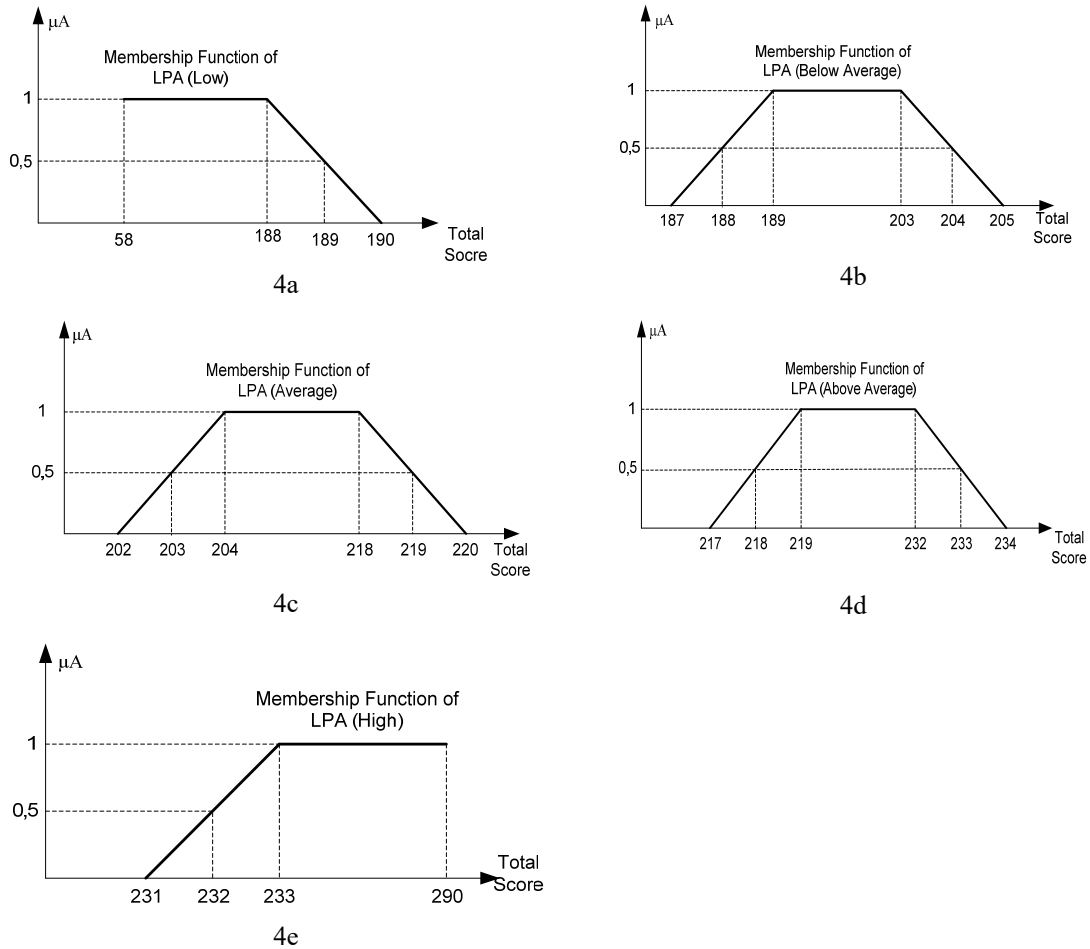


Figure 4: Trapezoidal Membership Function of Fuzzy for Each LPA Level

$$y^* = \frac{\sum y \mu_A(y)}{\sum \mu_A(y)} \tag{3}$$

Based on the graph of this membership function, we found that if the student had a total score of 219, it means that the score contribution of membership degree for each LPA level was 0.5 in the level of “average” and 1 for the level of “above average.” The membership degree of the other scores of LPA level can be found in the membership function graph above. To determine the total score of the fuzzy membership function used to evaluate LPA level in each study program of the computer field in Kupang involved in this study, we used Center of Area [32];[36];[9] formulated as follow:

where y is the crisp logic of the score and $\mu_A(y)$ is the membership degree of y .

For example, we determined Level of LPA based on trapezoid membership function of Low Level for Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang as follow:

$$LPA_L = \frac{\sum y \mu_R(y)}{\sum \mu_R(y)} = \frac{0*1+1*0.5+0*0}{1+0.5+0} = \frac{0+0.5+0}{1.5} = 0.33$$

The recap of LPA scores of all participants from five study programs of the computer field in Kupang City involved in this research was used to determine the fuzzy score of each LPA level in

every study program by using the formula of Center of Area. The calculation results of a fuzzy score of each LPA level of all groups are shown in Table 3.

Table 3: Learning Preference Assessment Based on Fuzzy Logic Method

Study Program	Level LPA					
	High	Above Average	Average	Below Average	Low	
	Diploma Program in Informatics Engineering, Computer Science Academy	0.80	0.50	0.83	0.50	0.67
	Undergraduate Program of Informatics Engineering, Computer Science Academy	0.67	0.92	0.83	0.75	0.67
	Undergraduate Program of Information System, Computer Science Academy	0.86	0.94	0.95	0.80	1.33
Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang	0.67	0.80	0.75	0.75	0	
Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang	0.67	0.89	0.92	0.95	0.33	

To answer the research question whether there is a difference of result of the LPA level measurement between using statistic method and using the fuzzy method, we did not conduct the difference test statistically because the type and approach of both data were different. The statistical method used mathematical and classical logic

approaches while fuzzy method used mathematical and cognitive approaches so that the results could be explained only in descriptive-qualitative that was seeing whether there was a difference of the data between the statistical analysis table and fuzzy analysis table [8].

We found that the fuzzy system could give the difference of LPA level in some groups. As a comparison, if we used statistical and classical logic methods (see Table 2), we found the total number of students with the “low” level in Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang, and Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang was similar, but by using the fuzzy logic system (see Table 3), it was found the difference: Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang = 0, Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang = 0.33. It means that actually in Diploma Program in Computer and Network Engineering and State Polytechnic of Kupang there were the students with the “low” LPA level. All analysis before strengthens that the application of fuzzy logic principles could describe the condition more objectively and effectively for the studies that have the uncertainty level [39];[40].

The analysis results give practical implication on the online learning. If we increase the self-directed learning readiness scale to be involved in online learning, we will give the similar intervention for Diploma Program in Computer and Network Engineering, Engineering Academy of Kupang, and Diploma Program in Computer and Network Engineering, State Polytechnic of Kupang when we refer to the results of statistical analysis. Whereas in fact, we should prioritize the intervention for Diploma Program in Computer and Network, State Polytechnic since the membership degree of low level is bigger than the Diploma Program in Computer and Network and Engineering Academy of Kupang. For the other results, based on the Table 3, if we need to enhance the number of students in the LPA level of “above the average”, we have to take the Diploma Program in Informatics Engineering, Computer Science Academy as the priority to intervene the treatment that can make the score of LPA level similar to the other study programs of the computer field. These results also showed that the right LPA analysis can be a beneficial tool to determine the students’

learning need to improve the self-directed learning skill. Besides, it is advantageous for the teacher to clearly understand the characteristics and self-directed learning skill for the further development [4].

These are the benefits of a fuzzy system that we recommend in this research. If we need a map of the self-directed learning readiness to be involved in online learning system in the university level or study program, we can utilize a fuzzy approach that can help the decision making for the process of self-directed learning improvement for online learning. This study can be conducted in the other areas or countries to validate these findings.

5. CONCLUSION

We have conducted a study of the application of the fuzzy logic principle to assess the self-directed learning readiness by using two approaches namely statistic and fuzzy logic. The research results showed that there was a difference of the results of LPA level score between using the statistical method and using the fuzzy logic method. The fuzzy system could find the different LPA level that could not be found by using statistical or classical logic analysis. Due to the goodness of fuzzy logic that can give mathematical reinforcement for the perception and linguistic data regarding human's cognitive aspect and theory of fuzzy logic can provide the inference mechanism in the uncertainty level.

The findings of this research practically give impact in the learning activity. The learning provider can give different intervention to the universities in preparing the students to be involved in online learning. The weakness of the fuzzy logic system recommended is this system has not been able to classify the potential and weakness of each student accomplishing the questionnaire of LPA so that the ideal topic for further research is applying the fuzzy logic technique such as Artificial Neural Network Fuzzy Inference Systems (ANFIS), or the other algorithms of soft computing.

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