Robust Estimation of Student Performance in Massive Open Online Course using Fuzzy Logic Approach

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ABSTRACT

The objective of this paper is to develop robust estimation of student performance in Massive Open Online Course (MOOC) using fuzzy logic approach. A massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the web. This evaluation for MOOC was implemented using online assessment marks and online self-learning time. Data were collected from 30 students who were participated in online course. Data for online assessment marks was represented using trapezoidal membership function. Meanwhile, data for online self-learning time was represented using triangular membership function. Output data for this analysis using final examination marks with gaussian membership function. Fuzzy logic procedure involved in this study using three procedures namely fuzzification of all inputs, fuzzy inference process using rule base and defuzzification to get output values. Results indicated higher value online assessment marks and higher value of online self-learning time contributed to higher performance in final examination. The findings of this study will help educators to forecast student performance in final examination with considering online input variables namely online assessments marks and online self-learning time. This study also will help students to adjust their self-learning time in obtaining required expected result in final examination.

Keywords : *Fuzzy logic, Massive open learning course (MOOC), Student performance, Final Examination.*

I. INTRODUCTION

In the global educational system and the increasing of Artificial Intelligent system creating more tightly integrated system between traditional learning with online learning on higher education system in Malaysia. Therefore, education systems in Malaysia become more effective and efficient. Teaching and learning is important process in order to deliver a course in the good learning experience environment. Learning is the process of acquiring relative permanent changes in understanding, attitude, knowledge, information, capacity and ability through experience [1]. Therefore, various methods of teaching and learning were introduced in order to achieve the objective of teaching and learning. Course Learning Outcome (CLO) is the benchmark of course output [2] that describe what students will know and be able to do upon successful complete a program or course.

Online learning is the educational tool based on the Internet. Online learning used electronic technologies to access educational curriculum outside of a traditional classroom. In most cases, it refers to a course, program or degree delivered completely online. Therefore, students must access to internet before they start learning. All the material for teaching and learning are uploading in the online system. Students must access the internet in order to excess the material for the courses that they register. This system gives benefit to students to study without follow the timetable for attending a class. Thus, online learning appears to have the power to change the education landscape [3].

MOOC online learning was introduced under the Ministry of Education, Malaysia (MOE). MOOC provided opportunities for thousands of learners to participate in free higher education courses online [4]. MOOC is an open online learning that allowed students to access a course everywhere they live. Students just need to online register on MOOC system then their can watch the video according to the subject that they register. This system is easy and friendly. It also allowed students to watch the video in everywhere such as, student can access MOOC online learning in hostel, library, restaurant and others place. This teaching and learning style give self-determination to student to learn without followed the timetable for attend to classroom.

The MOOC initiative is part of the Ministry of

Education's strategic plan to increase the quality and accessibility of higher education. Malaysian universities will develop MOOC on core modules and students from other public universities will participate in those courses through MOOC online learning website. The students from public and private universities can access by register under MOOC online learning website. The first stage of MOOC online platform implementation in year 2014, using these courses:

(i) ICT Competency course led by Universiti Malaysia Sarawak;

(ii) Introduction to Entrepreneurship course led by Universiti Teknologi MARA;

(iii) Ethnic Relations course led by Universiti Kebangsaan Malaysia; and

(iv) Islamic Civilization & Asian Civilization course led by Universiti Putra Malaysia.

The development of MOOC online learning was pertained with the adoption of information and communication technology in Malaysian education. It also created awareness and readiness for MOOC online learning amongst Malaysian students [5]. The development of technology was improved the teaching and learning environment with integration of formal and informal teaching and learning style in order to shift the environment learning.

Even there are many advantages used MOOC online learning in the teaching and learning process but the problem faced by students and lecturers is how to communicate and measure the performance of student including monitoring student learning time, assessing assignment, quizzes, examination and other exercises. Therefore, lecturers must have a good indicator in assessing the performance of students. Thus, this study tries to suggest a good indicator in measuring the performance of students by investigate the performance of students enroll in MOOC online learning using online assessment marks and online self-learning time. This study used fuzzy logic approach. Fuzzy logic is an approach to variable processing that allows for multiple values to be processed through the same variable. Fuzzy logic also attempts to solve problems with an open, imprecise spectrum of data that makes it possible to obtain an array of accurate conclusions. Fuzzy logic was designed to solve problems by considering all available information and making the best possible decision given the input. It also provides an effective means for conflict resolution of multiple criteria and better assessment of options [6]. This theory proposed in terms of the membership function operating over the range [0, 1] of real numbers. New operations for the calculus of logic were also proposed and showed to be in principle at least a generalization of classic logic [7-9].

II. LITERATURE REVIEW

Internet and Artificial Intelligence (AI) are main technologies used in education and universities. A good lecturer not only should know their material but should also know a lot about the process of teaching and improve the skills especially in the millennial era [10].

One of the problems faced by lectures is the assessment of their students' knowledge and skills. In fact, our society demands not only to educate, but also to classify the students according to their qualifications as being suitable or unsuitable for carrying out certain tasks or holding certain posts [7]. Therefore, various methods of assessment are introduced. MOOC is one of the teaching and learning method implement in Malaysian universities. MOOC differ from traditional online courses as students participating in the courses are massive – scaling up to thousands of students per course [11-12]. The first MOOC started in year 2008 was introduced by George Siemens and Stephen Downes. The movement in offering MOOC spread to Europe where two major autonomous MOOC projects were initiated: OpenupEd and FutureLearn. OpenupEd was launched in year 2013 and Futurelearn started their first course in September 2015 [13].

MOOC has a potential capacity to influence higher education in a variety of ways such as students, educators and institutions. Firstly, for students, the systems can influence and shape or structure their approaches to learning and may stimulate class communication. Secondly for educators, MOOC may assist the development and selection of online resources and change traditional teaching practices. Lastly for institutions and researchers, MOOC can provide large data sets which can be analyzed and used to investigate more deeply the processes of learning and learner behavior [14].

According to Wong [15] the factors leading to effective teaching of MOOC revolve six areas according to the stages of course delivery namely, preparation, attraction, participation, interaction, consolidation and post-course support. Drago and Wagner [16] suggest that online students are more likely to have stronger visual and read-write learning styles. Zapalska and Brozik [3] identify teaching strategies in online courses while recognize four learning styles and concluded that the achievement of online learning can be improved by providing instruction in a manner consistent with each student's learning style. However, it is important to keep in mind that, even if a specific student learns best in a certain way, he or she should be exposed to a variety of learning experiences to become a more versatile online learner. The empirical results suggest that self-efficacy, self-enjoyment, self-development and social norm are positively associated with individuals' continuance intention of MOOC, while management commitment in the university has little influence on continuance intention. The moderating test further suggests that males are more likely to be influenced by self-development and perceived usefulness compared with females [17].

Koukis and Jimoyiannis [18] showed that MOOC can provide an efficient environment to enhance the pedagogy of knowledge and classroom practices and to support continuous professional development. According to Chen [19] MOOC can be traced back to distance learning when, though underprivileged such as living in the country side or remote area, people can still have a chance to be educated. Recently, MOOC have received a great deal of attention from the media, entrepreneurial vendors, education professionals and technologically literate sections of the public. The promise of MOOC is that will provide free to access, cutting edge courses that could drive down the cost of university-level education and potentially disrupt the existing models of higher education [20]. MOOC generated a significant media attention for their potential to disrupt the traditional modes of education trough ease of access and free or low-cost content delivery. MOOC also offer the potential to enable access to high-quality education to students, even in the most underserved regions of the world [21].

There are many studies investigated MOOC online learning use questionnaire and interview, but study that use Artificial Intelligent method namely fuzzy logic approach is still lack of researchers. Therefore, this study developed a robust estimation of student performance in MOOC using fuzzy logic approach. Fuzzy logic dates back to 1965 and it is related not only to current areas of knowledge, such as control theory and computer science, but also to traditional ones, such as philosophy and linguistics [22]. Researches used fuzzy logic approach in different area such as computer sciences [23], control system [24], operation management [25,26] and others. Thus, this study gives a new insight in teaching and learning environment in Malaysia by investigates the performance of students enroll in MOOC online learning using fuzzy logic approach.

III. METHODOLOGY

This section describes methodology of classification for student performance using fuzzy logic approach with considering two inputs namely online assessment marks and online self-learning time. Figure 1 shows the flowchart of research steps in implementing fuzzy logic for estimating student performance in final examination. The analysis starts with data selection, fuzzification of all inputs using fuzzy membership function, fuzzy inference process using rule base, and defuzzification of output values. Next, the outcome of fuzzy logic analysis needs to compare again with actual data, to reduce error in estimation and forecasting student performance in final examination.

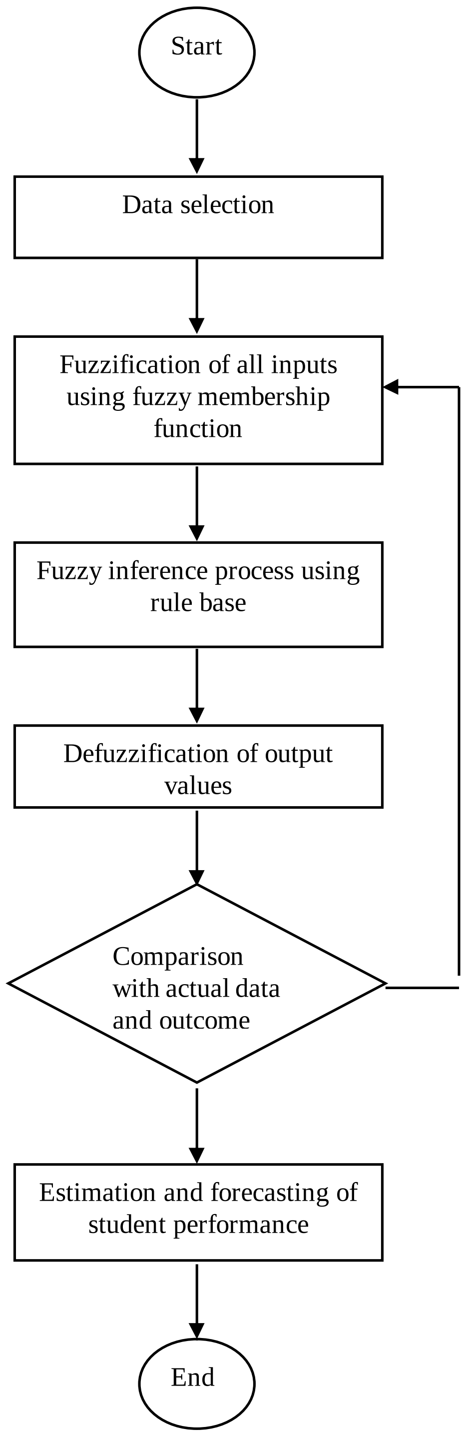

Figure 1: Fuzzy logic procedure for estimating student performance in final examination of online course

A. Data selection

In this study, data of 30 students are collected from one of courses that implemented massive open online course (MOOC) method. Table 1 indicates the distribution of students marks for online assessment, self-learning time and final examination performance. The range of online assessment attainment is set as one to ten. In the same time, the self-learning time for online course for each of students also is range to one until ten, in producing a valid and reliable finding. Then, the output variable is set as performance in final examination, and the data range is set from one to ten. All of these three variables are set as similar range in providing a robust estimation of student performance. Table 1 shows there are five students are excellent level, 20 students are moderate level and five students are poor level.

Table 1: Data for 30 students involved in MOOC analysis

Student Number	Online assessment marks	Self learning time	Final exam marks	Group
1	9	10	9	Excellent
2	8	9	8	Excellent
3	10	10	10	Excellent
4	9	9	9	Excellent
5	9	8	8	Excellent
6	5	7	6	Moderate
7	6	5	5	Moderate
8	6	8	7	Moderate
9	7	7	7	Moderate
10	5	6	6	Moderate
11	5	5	5	Moderate
12	7	7	7	Moderate
13	6	5	6	Moderate
14	6	6	6	Moderate
15	5	5	5	Moderate
16	6	7	7	Moderate
17	7	6	7	Moderate
18	6	5	6	Moderate
19	6	6	6	Moderate
20	7	7	7	Moderate
21	5	5	5	Moderate
22	6	7	7	Moderate
23	5	6	6	Moderate
24	7	7	7	Moderate
25	5	5	5	Moderate
26	1	2	2	Poor
27	3	1	3	Poor
28	1	1	1	Poor
29	3	4	4	Poor
30	2	1	2	Poor

B. Fuzzification of input variables using membership function

This study using two variables input namely online assessment marks and self-learning time. Both of these variables need to be translated membership function of fuzzy set. Fuzzification is to convert crisp inputs to fuzzy sets.

Membership function of fuzzy set is a graph that defines how each point in the input space is mapped to membership value between 0 and 1. Input space is often referred as the universe of discourse or universal set (u), which contain all the possible elements of concern in each particular application.

Next, this study explained the procedure of mathematical derivation for fuzzy logic process. The fuzzy set Ã in the universe of information U can be defined as a set of ordered pairs and it can be represented mathematically as Equation (1).

$$\tilde{A}=\left\{\left(y,\mu_{\tilde{A}}(y)\right)\middle| y\in U\right\} \quad \text{.............................. (1)}$$

In Equation (1), the parameters are described as follows: The parameter $\mu_{\tilde{A}}(\bullet)$ is membership function of $\tilde{A}$. Value for membership function is takes range from zero to one, $\mu_{\tilde{A}}(\bullet)\in[0,1]$. The membership function $\mu_{\tilde{A}}(\bullet)$ maps U to the membership space M. The dot $(\bullet)$ in the membership function represents element in fuzzy set which are discrete or continuous.

For membership function, there are three segments that decides the function characteristics namely core, support and boundary. For any fuzzy set $\left(\tilde{A}\right)$, the core of a membership function is that region of universe that is characterize by full membership in the set. Hence, core consists of all those elements, *y* in such that the universe of information is explained using Equation (2).

$$\mu_{\tilde{A}}(y)=1 \quad \text{... (2)}$$

Next, for any fuzzy set $\left(\tilde{A}\right)$, the support of a membership function is the region of universe that is characterize by a nonzero membership in the set. Therefore, core consists of all those elements, *y* of the universe of information that explained in Equation (3).

$$\mu_{\tilde{A}}(y)>0 \quad \text{... (3)}$$

Then, the third segment is boundary element. For any fuzzy set $(\tilde{A})$, the boundary of a membership function is the region of universe that is characterized by a nonzero but incomplete membership in the set. Hence, core consists of all those elements, *y* the boundary element for universe of information can be illustrated using Equation (4).

$$1 > \mu_{\tilde{A}}(y) > 0 \quad \ldots\ldots (4)$$

Next, this study performed fuzzification using membership functions for inputs and output. Fuzzification is defined as process of transforming a crisp set to a fuzzy set or a fuzzy set to fuzzier set. There are two type of fuzzification method namely support fuzzification (s-fuzzification) method and grade fuzzification (g-fuzzification) method.

First type of fuzzification, support fuzzification translate crisp values to fuzzy set in Equation (5).

$$\tilde{A} = \mu_1 Q(x_1) + \mu_2 Q(x_2) + \ldots + \mu_n Q(x_n) \quad \ldots\ldots (5)$$

The fuzzy set, $\tilde{A}$ in Equation (5) is kernel of fuzzification. This method is implemented with assumptions that underlying of fuzzification process with μ_i is constant and x_i is transformed to a fuzzy set $Q(x_i)$.

Second type of fuzzification method is grade fuzzification. This g-fuzzification method is developed using Equation (6) with assumptions of x_i is constant and μ_i is expressed as a fuzzy set.

$$\tilde{A} = x_1 Q(\mu_1) + x_2 Q(\mu_2) + \ldots + x_n Q(\mu_n) \quad \ldots\ldots (6)$$

a) Trapezoidal membership function for fuzzification

First input variable is online assessment marks using trapezoidal membership function. The trapezoidal function is described using Equation (7):

$$\text{Trapezoidal function } (x;a,b,c,d) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \\ 0, & d < x \end{cases}$$

…(7)

In Equation (7), the *x* variable represents real value (crisp value) within the universe of discourse. Next, a, b, c, d values represent a *x*- coordinates of the four heads for the trapezoidal and values should validate the following condition:

$$a < b < c < d \quad \ldots\ldots (8)$$

According to Equation (7), the real value of *x* variable that less than element point *a*, contributes to zero degree of membership function. Next, when the x value is between element point of a and b, the degree of membership increases closer to the element of *b*. Then, the real values that lies between *b* and *c* is the degree of membership 1.

Meanwhile, for the elements located between point *c* and *d*, the closer to the element of *d*, membership will be decrease approaching to zero. Then, membership degree become zero, in condition of x variable is larger than element point *d*.

B. Triangular membership function for fuzzification

Second input variable is self-learning time for online course that represented using triangular membership function. The triangular membership is defined by Equation (9).

$$\text{Triangular function } (x;a,b,c) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & c < x \end{cases}$$

………(9)

Where a and b and c represent the *x*-coordinate for capital triangle, *x* represents the real value (crisp value) from the private variable fuzzy universe of discourse.

Function outputs ranging between 0 and 1 and represents the value of the degree of membership of *x*. The point *b* has a value of 1 membership degree. The membership degree of elements increasing when location of *x* between a and b closer to the element of b. Meanwhile, the *x* element located between b and c are considerably less degree its membership slowly closer to the element of c. The requirement of elements should fulfill Equation (10).

$$a < b < c \quad \ldots\ldots (10)$$

C. Gaussian membership function for fuzzification

The output variable in this study is using final examination performance in scale of one to ten. The output variable was represented using Gaussian membership function. The fuzzy membership values computed using the following Gaussian membership function in Equation (11).

Gaussian function (x;σ,c)= $\begin{cases} e^{-\frac{(x-c)^2}{2\sigma^2}} \end{cases}$ ……………(11)

In Equation (11), the parameter σ is standard deviation and c is mean value for Gaussian membership function. Membership values are computed for each input value in x.

Gauss function is the popular function considered among the most membership functions for the following reasons:

(i) Smoothness of function applicable where dealing with continuous values.

(ii) It does not include options and multiple conditions compared to the previous functions.

(iii) All values are non-zero.

C. Fuzzy inference process using rule base approach using fuzzy logic operator

Fuzzy logic operator works with membership values in a way that mimics Boolean logic. A simple algorithm of fuzzy logic function synthesis introduced concepts of constituents of minimum and maximum. A fuzzy logic function represents a disjunction of constituents of minimum, where a constituent of minimum is a conjunction of variables of the current area greater than or equal to the function value in this area. Table 1 indicates the fuzzy inference process with rule base.

Table 1: Fuzzy inference process

Boolean	Fuzzy
AND (x, y)	MIN (x, y)
OR (x, y)	MAX (x, y)
NOT (x)	1 – x

Fuzzy inference system is the main component of a fuzzy logic system to develop valid and reliable decision-making process as its primary work. It is implemented IF-THEN rules with combination of operators AND, OR operators for essential decision rules.

As in classical logic, in fuzzy logic there are three basic operations on fuzzy sets: union, intersection and complement.

(i) Union operator: Let μ_A and μ_B be membership functions that define the fuzzy sets A and B, respectively, on the universe X. The union of fuzzy sets A and B is a fuzzy set defined by the membership function in Equation (12).

$$\mu_{A\cup B}(x) = \text{Max}\left(\mu_A(x), \mu_B(x)\right) \quad \ldots\ldots\ldots\ldots\ldots (12)$$

(ii) Intersection operator: Let μ_A and μ_B be membership functions that define the fuzzy sets A y B, respectively, on the universe X. The intersection of fuzzy sets A and B is a fuzzy set defined by the membership function in Equation (13).

$$\mu_{A\cap B}(x) = \text{Min}\left(\mu_A(x), \mu_B(x)\right) \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

(iii) Complement operator: Let μ_A be a membership function that defines the fuzzy set A, on the universe X. The complement of A is a fuzzy set defined by the membership function in Equation (14).

$$\mu_{A^c}(x) = 1 - \mu_A(x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

There are five main components of fuzzy inference systems in developing a reliable decision from crisp inputs to crisp outputs. The five main components are described as follow:

(i) Rule base: This component describes IF-THEN rules for fuzzy system.

(ii) Fuzzy database: It defines the membership functions of fuzzy sets used in fuzzy rules.

(iii) Decision making unit: This element performs rule computation.

(iv) Fuzzification interface unit: This component converts the crisp quantities into fuzzy quantities.

(v) Defuzzification Interface Unit: This element converts the fuzzy quantities into crisp quantities.

Figure 2 shows the interaction between five components in fuzzy logic system. The interaction of this element contributes a reliable fuzzy logic decision. A fuzzification unit supports the application of numerous fuzzification methods, and converts the crisp input into fuzzy input. Then, A knowledge base is described as collection of rule base and database is formed upon the conversion of crisp input into fuzzy input. The defuzzification unit fuzzy input is finally converted into crisp output.

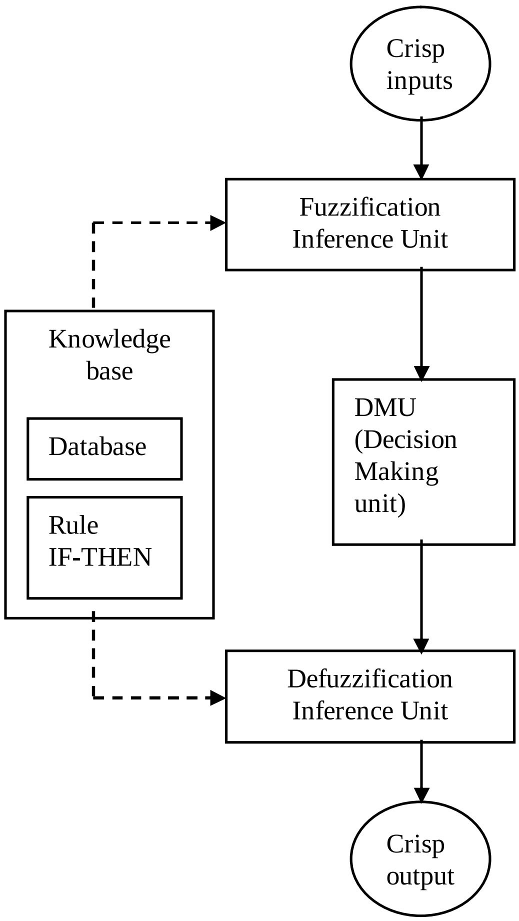

Figure 2: Block diagram of fuzzy inference system

D. Defuzzification process using centroid method.

Defuzzification is the process of obtaining a single number from the output of the aggregated fuzzy set. Defuzzification also may be defined as the process of reducing a fuzzy set into a crisp set or to convert a fuzzy member into a crisp member. The function of defuzzification is used to transfer fuzzy inference results into a crisp output. In this study, centroid defuzzification method is selected for transforming output value.

Centroid defuzzification returns the center of area under the curve. This method is also known as the center of area or the center of gravity method. This method finds the center point of the targeted fuzzy region by calculating weighted mean of output fuzzy region. Mathematically, the de-fuzzified output, x^* is represented by Equation (15).

$$x^* = \frac{\int \mu_{\tilde{A}}(x).xdx}{\int \mu_{\tilde{A}}(x).dx} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(15)}$$

Centroid defuzzification also can be re-arranged in Equation (16).

$$g = \frac{\sum_{i=1}^{n} x_i \cdot \mu(x_i)}{\sum_{i=1}^{n} \mu(x_i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(16)}$$

In Equation (16), the membership function of defuzzification is represented by $\mu(x_i)$ and for each of variable is represented by x_i in coordinate system

IV. RESULT AND DISCUSSION

This study evaluated the status of student performance in massive open online course suing two input variables namely online learning self-study time and online assessment mark. Figure 3 shows triangular membership function for input variable namely online self-study learning time. Triangular membership function for is set for three group of student competency namely poor, moderate and excellent.

The first level, poor student in online learning time is represented by Equation (17).

$$\text{Triangular function} = \begin{cases} \frac{4-x}{4-0}, & 0 \le x \le 4 \\ 0, & 4 < x \end{cases} \quad \ldots\ldots\ldots \text{(17)}$$

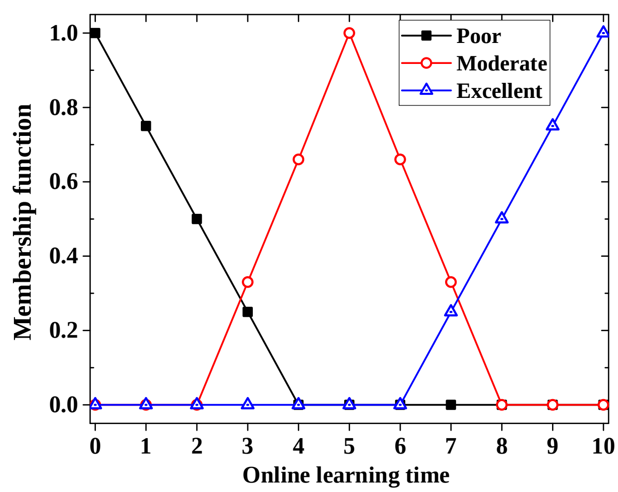

Figure 3: Triangular membership function for online learning time

Meanwhile, the second competency level is moderate that represented by Equation (18).

$$\text{Triangular function} = \begin{cases} 0, & x < 2 \\ \frac{x-2}{5-2}, & 2 \le x \le 5 \\ \frac{8-x}{8-5}, & 5 \le x \le 8 \\ 0, & 8 < x \end{cases} \quad \ldots\ldots\ldots \text{(18)}$$

The excellent level for online learning time is represented by Equation (19).

$$\text{Triangular function}=\begin{cases}0, & x<6 \\ \dfrac{x-6}{10-6}, & 6\le x\le 10\end{cases} \quad \text{.........} (19)$$

Figure 4 shows trapezoidal membership function for input variable namely online assessment marks. The first level is for poor marks represented by Equation (20).

$$\text{Trapezoidal function}=\begin{cases}1, & 0\le x\le 1 \\ \dfrac{4-x}{4-1}, & 1\le x\le 4 \\ 0, & 4<x\end{cases} \quad \text{.........} (20)$$

Next, the second level which is moderate level for online assessment marks is represented by Equation (21).

$$\text{Trapezoidal function}=\begin{cases}0, & x<2 \\ \dfrac{x-2}{4-2}, & 2\le x\le 4 \\ 1, & 4\le x\le 6 \\ \dfrac{8-x}{8-6}, & 6\le x\le 8 \\ 0, & 8<x\end{cases} \quad \text{.........} (21)$$

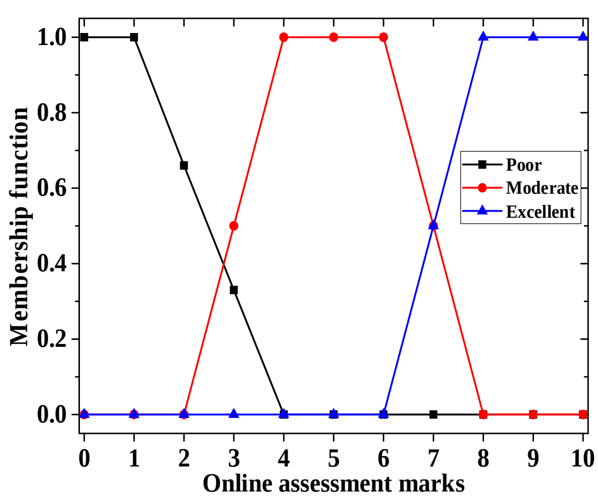

Figure 4: Trapezoidal membership function for online assessment marks

Next, the third level of online membership functions for excellent of online assessment marks is represented by Equation (22).

$$\text{Trapezoidal function}=\begin{cases}0, & x<6 \\ \dfrac{x-6}{8-6}, & 6\le x\le 8 \\ 1, & 8\le x\le 10\end{cases} \quad \text{.......} (22)$$

The output variable which is final examination performance is represented using Gaussian membership function. Figure 5 shows Gaussian membership function for final examination performance. The poor level for final examination performance is described as Equation (23).

$$\text{Gaussian membership function} = \left\{ e^{-\frac{x^2}{2}} \right. \quad \text{............} (23)$$

Next, moderate level of final examination performance is represented by Equation (24).

$$\text{Gaussian membership function} = \left\{ e^{-\frac{(x-5)^2}{2}} \right. \quad \text{.........} (24)$$

Then, excellent level for final examination performance is represented by Equation (25).

$$\text{Gaussian membership function}= \left\{ e^{-\frac{(x-10)^2}{2\times(1.3)^2}} \right. \quad \text{........} (25)$$

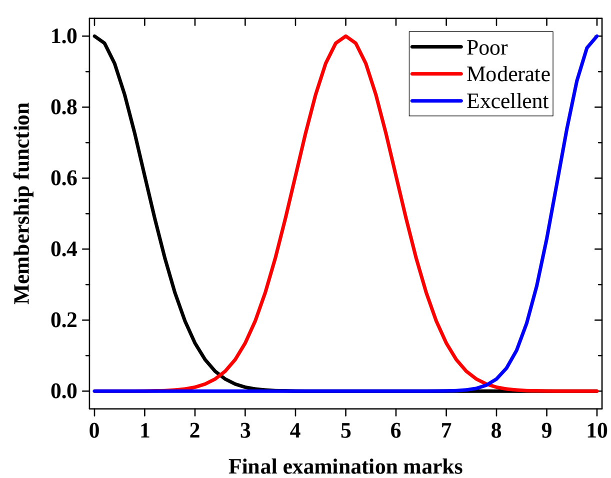

Figure 5: Gaussian membership function for final examination performance

Next, fuzzy inference phase using rule-based approach. In this study, five rules are implemented to integrated the two inputs variables with one output variables. The summary of rule is described in Table 2.

Table 2: Rules for fuzzy inference system

Rule	If input variable 1 (online assessment marks)	If input variable 2 (online self-learning time)	Outcome (Final exam performance)
1	Excellent	Excellent	Excellent
2	Moderate	Moderate	Moderate
3	Poor	Poor	Poor
4	Excellent	Poor	Moderate
5	Poor	Excellent	Moderate

Then, this study performed defuzzification to evaluate the classification of student performance in final exam with respect to input from two input variables. This study used centroid method to defuzzification process. Figure 6 shows three-dimension relationship between learning time and online marks with outcome of final examination marks. Figure 6 indicates low learning time and low online marks contributes low performance in final examination report. Meanwhile, high self-learning time and high online assessment marks contributes to higher performance in final examination.

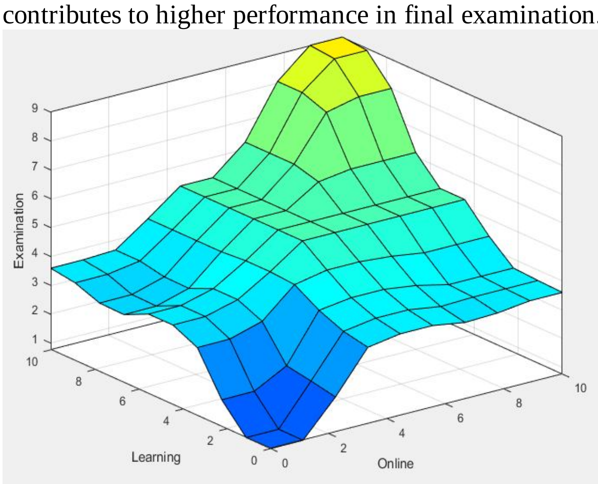

Figure 6: Three-dimensional correlational graph for two input and one output variable

Next, this study developed student performance mapping for estimating final exam performance for massive open online course. Figure 7 shows mapping of clustering for estimating student performance in final examination of massive open online course. Figure 7 indicates if online assessment marks is eight until ten in scale which is considered as high level, in the same time second input variable namely learning time also is eight to ten in scale which is considered as high level, contributes to estimation of particular student is able to get A-grade in final examination. This region is labelled using symbol of A that yellow-colored.

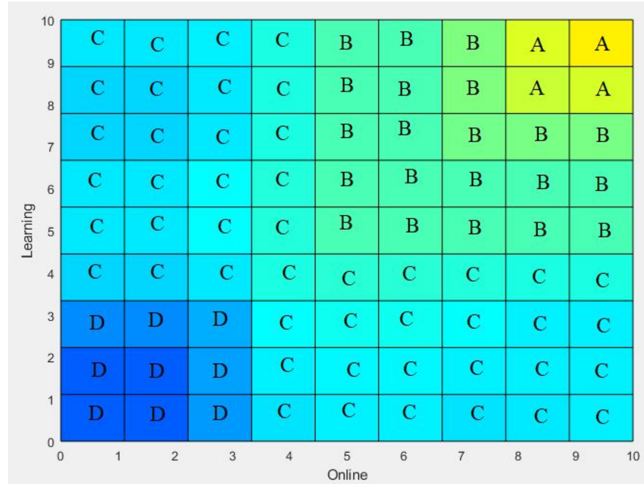

Figure 7: Mapping of clustering for estimating student performance in final examination

Next, students who are intend to perform preparation five to seven range for online self-learning, and collect five to seven range for online assessment marks, are estimate to obtain grade B in massive open online course in final examination. The grade of B in Figure 7 is clustered using light green area and labelled B.

Then, students who are involved with four hours online preparation and in the same time have four range of online assessments, that students are estimate to be in C-grade of final examination performance.

Next, the D-grade performance in final examination is defined by students who are spending time for online self-learning in range of zero to three hours and obtain online assessments marks between range of zero to three.

This study validated the estimation of mapping using fuzzy logic with actual data. The mapping result shows estimation of student performance in final examination is reliable as estimator in predicting student result

V. CONCLUSION

The objective of this study is to develop robust estimation for predicting student performance in final examination in massive open online course (MOOC). The two-input variables are selected namely self-learning time and online assessment marks. The main findings of this study are described as follow:

I. If online assessment marks are eight until ten in scale
which is considered as high level, in the same time second input variable namely learning time also is eight to ten in scale which is considered as high level, contributes to estimation of particular student is estimated to able to get A-grade in final

examination.

II. The mapping result shows estimation of student performance in final examination is reliable as estimator in predicting student result

The significant contribution of this study is to help course coordinator of massive open online course to monitor performance of students in final examination. The finding of this study can be use as guideline to advice student about level of effort to achieve desired grade in final examination.

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REFERENCES

[1] Machadoa, M.A.S., Moreira, T.D.R.G., Gomes, L.F.A.M., Caldeirad, A.M. and Santose, D.J. (2016). "*A fuzzy logic application in virtual education*". Procedia Computer Science, 91, 19 – 26.

[2] Lau, K., Lam, T., Kam, B., Nkhoma, M. and Richardson, J. (2018). "*Benchmarking higher education programs through alignment analysis based on the revised Bloom's taxonomy*". Benchmarking: An International Journal, 25 (8), 2828-2849.

[3] Zapalska, A. and Brozik, D. (2006). "*Learning styles and online education*". Campus-Wide Information Systems, 23 (5), 325-335.

[4] Yousef, A.M.F., Chatti, M.A., Wosnitza, M. and Schroeder, U. (2015). "*A Cluster Analysis of MOOC Stakeholder Perspectives*". International Journal of Educational Technology in Higher Education, 12, 74–90.

[5] Fadzil, M., Abdol Latif, L. and Munira, T.A. (2015). "*MOOCs in Malaysia: A preliminary case study. E-ASEM Forum: Renewing the Lifelong Learning Agenda for the Future*". Bali, Indonesia.

[6] Singh, H., Gupta, M.M., Meitzler, T., Hou, Z.G., Garg, K. K., Solo, A.M.G. and Zadeh, L.A. (2013). "*Real-Life Applications of Fuzzy Logic*". Advances in Fuzzy Systems, 1-3.

[7] Zadeh, L.A. (1965). Fuzzy sets. "*Information and Control*", 8 (3), 338-353.

[8] Voskoglou, M.G. (2013). "*Fuzzy Logic as a Tool for Assessing Students' Knowledge and Skills*". Education Sciences, 3, 208-221.

[9] Zadeh, L.A. (1968). "*Fuzzy algorithms*". Information and Control, 12, 94–102.

[10] Sasmoko, Budiharto, W. and Prabowo, H. (2019). "*Self-diagnostic using fuzzy logic for teaching learning quality improvement in universities*". ICIC Express Letters, 13 (3), 247–253.

[11] Nordin, N., Norman, H. and Embi, M. A. (2015). "*Technology acceptance of Massive Open Online Courses in Malaysia*". Malaysian Journal of Distance Education, 17(2), 1-16.

[12] Siemens, G. (2013). "*Massive open online courses: Innovation in education?*". In McGreal, R., Kinuthia W., & Marshall S. (Eds.) Massive open online courses: Innovation in (pp. 5-16). Commonwealth of Learning, Athabasca University.

[13] Chea, C.C. (2016). "*Benefits and challenges of massive open online courses*". ASEAN Journal of Open Distance Learning, 8 (1), 16-23.

[14] Almutairi, F. and White, S. (2018). "*How to measure student engagement in the context of blended-MOOC*". Interactive Technology and Smart Education, 15 (3), 262-278.

[15] Wong, B. (2016). "*Factors leading to effective teaching of MOOCs*". Asian Association of Open Universities Journal, 11 (1), 105-118.

[16] Drago, W. and Wagner, R. (2004). "*Vark preferred learning styles and online education*". Management Research News, 27 (7), 1-13.

[17] Shao, Z. (2018). "*Examining the impact mechanism of social psychological motivations on individuals' continuance intention of MOOCs*". Internet Research, 28 (1), 232-250.

[18] Koukis, N. and Jimoyiannis, A. (2019). "*MOOCS for teacher professional development: exploring teachers' perceptions and achievements*". Interactive Technology and Smart Education, 16 (1), 74-91.

[19] Chen, J.C. (2013). "*Opportunities and Challenges of MOOCS: Perspectives From Asia*". IFLA WLIC 2013, Singapore, 1-16.

[20] Yuan, L. and Powell, S. (2013). "*MOOCs and open education: Implications for higher education*". Centre for Educational Technology & Interoperability Standard, 1-19.

[21] Nathan M. Castillo, Jinsol Lee, Fatima T. Zahra and Daniel A. Wagner (2015). "*MOOCs for Development: Trends, Challenges, and Opportunities*". Information Technologies & International Development, 11 (2), 35-42.

[22] Sobrino, A. (2013) "*Fuzzy Logic and Education: Teaching the Basics of Fuzzy Logic through an Example (by Way of Cycling)*", Education Sciences, 3, 75-97.

[23] Stotts, L. and Kleiner, B. (1995). "*New developments in fuzzy logic computers*". Industrial Management & Data Systems, 95 (4), 22-27.

[24] Bannatyne, R. (1994), "*Development of fuzzy logic in embedded control*". Sensor Review,14 (3), 11-14.

[25] Oke, S. and Charles□Owaba, O. (2006). "*Application of fuzzy logic control model to Gantt charting preventive maintenance scheduling*". International Journal of Quality & Reliability Management, 23 (4), 441-459

[26] Saeed, S., Shaikh, A., Memon, M. A., Nizamani, M. A., & Memon, M. (2020). "*Online Deal Portal: Factors to Consider for an Effective Design*". *University of Sindh Journal of Information and Communication Technology*, *4*(1), 38-44.