Blended Learning Quality Measurement System using Fuzzy Analytic Hierarchy Process Method

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Keywords: Blended Learning, Synchronous, Asynchronous, Fuzzy Analytic Hierarchy Process, recommendations, COVID-19.

Abstract: Blended learning is appropriate learning in the era of the COVID-19 pandemic. Blended learning is a learning process that integration face-to-face and online learning. The characteristics of blended learning are learning that combines synchronous and asynchronous learning settings correctly to achieve learning objectives. The indicators in this study are live synchronous, virtual synchronous, independent synchronous and collaborative asynchronous. There are many indicators in the measurement of blended learning, so a method is needed to determine recommendations for improvement in the implementation of blended learning. The method used in this research is Fuzzy AHP. Fuzzy method can handle data that contains uncertainty and inaccuracy. The Fuzzy Analytic Hierarchy Process (AHP) method is used to determine the weighting of each blended learning indicator. The purpose of this research is to build a decision support system software to determine recommendations in implementing blended learning. Based on the research, that the indicators that most influence the quality of blended learning are problem based learning, task collaboration and independent tasks. The test results showed that the highest accuracy was obtained from a consistency ratio of 0.03627 with an accuracy of 98%.

1 INTRODUCTION

Coronavirus Disease 2019 or COVID-19 has infected millions of people worldwide and caused death. The Coronavirus outbreak has been declared a pandemic global by the World Health Organization (WHO). The COVID-19 pandemic affects almost all aspects of life, including education. In a pandemic like this, the role and position of the educational aspect is very crucial. Blended Learning is a learning strategy that aims to achieve learning by combining face-to-face learning and information technology-based learning conducted online (Eniyati et al., 2010). Blended learning means a integration of face to face with e-learning that can be used by anyone (everyone), anywhere, anytime (anytime) (Bruggeman et al., 2019). The term blended learning means a harmonious and ideal combination of learning or an integraion of face-to-face and online learning elements (Bruggeman et al., 2019).

Electronic Learning or E-Learning is an independent learning process by utilizing information and communication technology (ICT), or the internet as a medium for knowledge transfer (Jeffrey et al., 2014). The application of web-based learning (e-learning) is one of the supports in supporting conventional learning systems, because students and educators do not have to meet face to face. The world community has used e-learning a lot. the use of e-learning in schools, training, universities and industries, namely Cisco Systems, IBM, HP, Oracle, and others (Kustiyahningsih et al., 2018). Previous research e-Learning Quality Measurement based on ISO 19796-1 with Fuzzy Analytic Network Process Method (Kustiyahningsih et al., 2018)

The results of this study are recommendations for e-learning improvements based on the smallest weighting of the e-learning indicator value (Cahyani et al., 2015). In this study, blended learning indicators consist of Live Synchronous (Face-to-face, Problem Based, learning and learning methods), Virtual synchronous (online), Asynchronous standalone (Independent Tasks) Asynchronous Collaborative (Task Collaboration and Task Evaluation). Multi criteria decision making technique is useful for finding the best option from several alternatives. AHP technique is a multi-criteria decision making technique based on expert knowledge (Kaxancoglu et

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al., 2018; Kustiyahningsih et al., 2017). AHP cannot describe human thinking, so the Fuzzy AHP technique is developed (Sevit et al., 2017; Claudia et al., 2020). The problem of this research is the number of indicators in the measurement of blended learning, so a Decision Support System (DSS) is needed. The purpose of this research is to build software DSS to determine recommendations in implementing blended learning. Therefore in this study using the FAHP method to determine the indicators that most influence the implementation of blende learning.

2 RESEARCH METHODS

2.1 Blended Learning

The blended learning method, it combines face-to-face learning, appropriate setting and asynchronous learning. A learning experience that is more flexible, interactive, efficient, accessible, and varied for teachers and students is a blended learning concept. The adaptation of learning using technology and traditional is also a blended learning strategy. Appraisal evaluation is very important in determining the success rate of blended learning. Student learning using creative and innovative methods can provide innovative solutions in determining learning techniques (Jeffrey et al., 2014).

Blended learning supports more flexible, interactive, efficient, accessible, and varied learning for teachers and students. Blended learning approach lies in the adaptation of existing technology-assisted learning methods and traditional-based learning. Assessment is a very important tool for determining student knowledge for subjects at every level of education. Blended learning techniques provide instruction to deliver lectures and assess student learning using creative and innovative methods. In this journal studying the blended learning process, the advantages of using blended learning techniques in the education system. This journal also discusses assessment methods to consider in this learning technique. The blended learning method is very interesting because it is more complete online and face-to-face (Asif et al., 2012).

2.2 Characteristics of Blended Learning

The characteristics of blended learning using a constructive approach have two learning settings, namely synchronous and asynchronous learning, the follow is a picture of characteristics of blended learning [11].

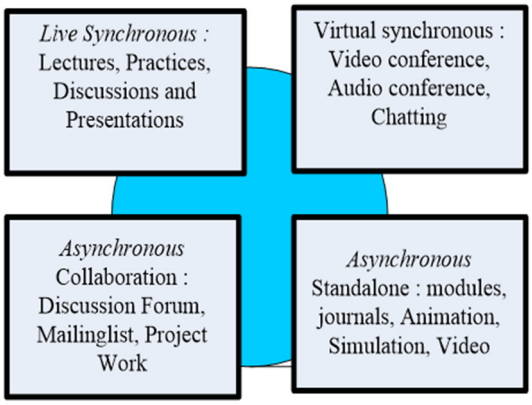

Figure 1: Characteristics and setting of blended learning with a constructive approach.

2.3 Fuzzy Analitycal Hierarchy Process (FAHP)

Fuzzy AHP is an analytical method developed from traditional AHP. Although AHP is commonly used in dealing with qualitative and quantitative criteria in MCDM, fuzzy AHP is considered better at describing vague decisions than traditional AHP (Tukan et al., 2020; Ozcalici et al., 2019). Conversion from AHP to Fuzzy AHP using Triangular Fuzzy Number (TFN) and converting into three real numbers, namely low, middle and upper. Fuzzy values provide strength to factors or indicators that contain data or values that are unclear or inaccurate (Abramovici et al., 2011; Tsyganok et al., 2016).

Table 1: Triangular Fuzzy Number (TFN) scale.

AHP's Intensity of Interest	Linguistic Societies	(TFN)	Reciprocal
1	Comparison of the same elements	(1, 1, 1)	(1, 1, 1)
3	One element is quite important over the other	(1,3/2, 2)	(1/2, 2/3, 1)
5	One element is more	(2,5/2, 3)	(1/3,2/5, 1/2)

	important than the other		
7	One element is more important than the other	(3,7/2, 4)	(1/4,2/7, 1/3)
9	One element is absolutely more important than the other	(4, 9/2, 9/2)	(2/9, 2/9, 1/4)

The steps of the FAHP are as follows (Citrawati et al., 2020; Saaty 2001):

1. Determine the pairwise comparison matrix between each criterion can be defined as follows:

$$X = \begin{bmatrix} 1 & x_{12} & x_{13} \dots & x_{1n} \\ x_{21} & 1 & x_{23} \dots & x_{2n} \\ x_{31} & x_{32} & 1 \dots & x_{3n} \\ \vdots & \vdots & \vdots \ddots & \vdots \\ x_{n1} & x_{n2} & x_{n3} \dots & 1 \end{bmatrix}$$

With $x_{ij} = (x^{l}_{ij}, x^{m}_{ij}, x^{u}_{ij})$, $x^{-1}_{ij} = (\frac{1}{x^{u}_{ij}}, \frac{1}{x^{m}_{ij}}, \frac{1}{x^{l}_{ij}})$

i,j = 1,2,...,n.

2. The geometric mean is used to determine the weighted value of the indicator based on the group of ratings. The calculation of the S matrix as a geometric mean is as follows

$$S = \begin{bmatrix} s_{11} & s_{12} & s_{13} \dots & s_{1n} \\ s_{21} & s_{22} & s_{23} \dots & s_{2n} \\ s_{31} & s_{32} & s_{33} \dots & s_{3n} \\ \vdots & \vdots & \vdots \ddots & \vdots \\ s_{n1} & s_{n2} & s_{n3} \dots & s_{nn} \end{bmatrix}$$

with *i,j = 1,2,...,n.*

$$s_{ij} = \left(\left(\prod_{k=1}^{n} x^{l}_{ijk} \right)^{1/n}, \left(\prod_{k=1}^{n} x^{m}_{ijk} \right)^{1/n}, \left(\prod_{k=1}^{n} x^{u}_{ijk} \right)^{1/n} \right),$$

3. Calculate matrix S for criterion weight. U is the results of the matrix criterion weight S.

$$U = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ \vdots \\ u_n \end{bmatrix},$$

$$u_i = \left(\frac{\prod_{j=1}^{n} (s^{l}_{ij})^{1/n}}{\sum_{i=1}^{n} s^{u}_{ij}}, \frac{\prod_{j=1}^{n} (s^{m}_{ij})^{1/n}}{\sum_{i=1}^{n} s^{m}_{ij}}, \frac{\prod_{j=1}^{n} (s^{u}_{ij})^{1/n}}{\sum_{i=1}^{n} s^{l}_{ij}} \right), \quad \text{With i,j = 1,2,...,n.}$$

4. Calculate BNP
Best Nonfuzzy Performance (BNP) method is used to convert the fuzzy output into crisp values. BNP can be stated as follows:

$$BNP_i = \frac{(u^{u}_{i} - u^{l}_{i}) + (u^{m}_{i} - u^{l}_{i})}{3} + u^{l}_{i},$$

With i = 1,2,...,n

3 RESULT AND DISCUSSIONS

3.1 Blended Learning Indicator

The indicators of the quality of blended learning examined here are live synchronous, virtual synchronous, independent asynchronous and collaborative asynchronous, where each indicator consists of several processes. Live synchronous: face-to-face, problem-based learning strategies (problem based learning), Lectures, practices, discussions, presentations, demonstrations, and others. Virtual synchronous: Learning is carried out at the same time but in the same / different room dimensions, including: video conference, audio conference, chat.

Virtual synchronous is an extension of live synchronous by utilizing technology to take a role in online learning. Independent asynchronous: Learning is carried out in different dimensions of space and time (anytime and anywhere) through learning media that allows students to learn independently through printed media in the form of books, magazines, modules. Asynchronous collaborative: Includes: project work, mailing lists, discussion forums; Provide opportunities for students and teachers to discuss, observe, investigate, and analyze problems related to material in online learning.

Table 2 presents data regarding the list of processes for each indicator used as follows:

Table 2: Blended learning indicator.

No	Criteria	Sub Criteria	Information
1	*Live Synchronous*	Face to Face (C1)	• 14 Times • 10 Times • 8 Times • 5-7 Times • 0-4 Times
		Problem Based Learning (C2)	• 4 Case Studies / exercises • 3 Case Studies / exercises • 2 Case Studies / exercises • 1 Case Studies / exercises • No Case Studies
		Learning Methods (C3)	• Lectures, Practices, Discussions and Presentations • Lectures, Practices, and Discussions • Lectures and Practices • Lecture • No Learning Methods
2	Virtual Synchronous	Online (C4)	• Video conference, Audio conference, Chatting • Video conference, Chatting • Audio conference, Audio conference • Chatting • Nothing
3	*Asynchronous* Standalone	Independent Task (C5)	• Doc, ppt, pdf, books, modules, journals • Doc, ppt, pdf, module, journal • Doc, ppt, journal, book • Doc, module • Nothing
4	*Asynchronous* Collaboration	Task Collaboration (C6)	• Discussion forums, mailing lists, project work • Discussion forums, project work • Mailing list, project work • Project work • Nothing
		Task Evaluation (C7)	• UAS, UTS, Post test Pretest • UAS, UTS, Post test • UAS, UTS • UAS • Nothing

3.2 System Design

The system design is made to build a blended learning quality measurement system including flowcharts and use cases to be implemented. The purpose of making this system design is so that the system will be more focused and have a reference so that it will be easier when implementing the programming language.

FAHP Flowchart, The following is a flowchart of the AHP Fuzzy Method can be seen at Figure 2.

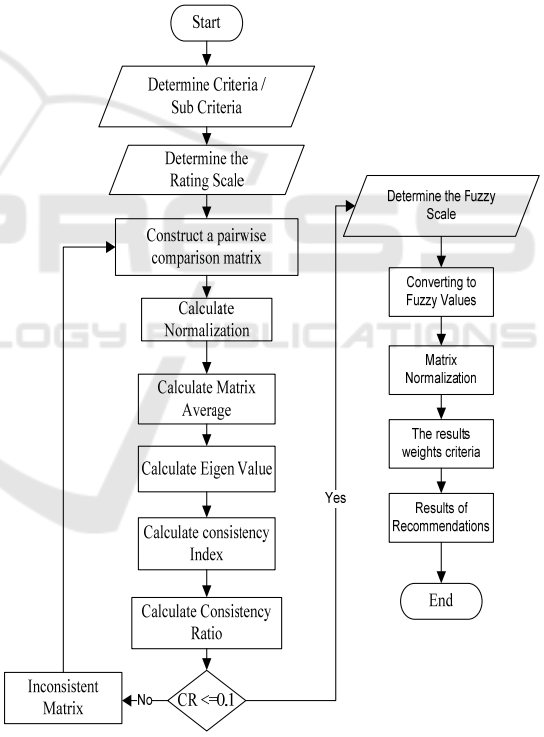

Figure 2: Flowchart FAHP.

Based on Figure 2. The first step is to determine the criteria and sub-criteria, then the linguistic scale of the criteria and enter the level of importance obtained from the expert assessors. Based on the pairwise comparison matrix looking for normalization, eigen value, index consistency and consistency ratio. If consistency ratio of 10% then to the next step and if the consistency ratio is more than

10% then a re-evaluation of each criterion is carried out. The next step after CR is less than 10%, determine is low, middle and upper fuzzy scales. Convert to Triangular Fuzzy Number (TFN) to form Low, Middle, Upper (L M U). Defuzzyfication process is with Best Non Fuzzy performance (BNFP). Enter the weight of blended learning. The priority of the criteria matrix is multiplied by the priority of the blended learning and the last alternative preference results.

Use Case Diagram is an explanation of the functionality of a system or class and how the system interacts with the outside world. Use case diagrams for a blended learning quality measurement system can be seen at Figure 3.

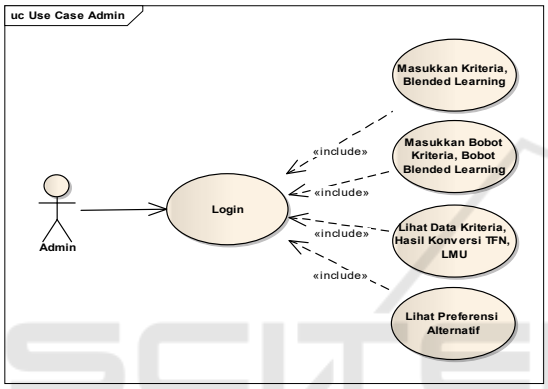

Figure 3: Use case diagram.

Based on Figure 3, users or actors who must log in before accessing all pages. The actor is Admin, where the admin is a system user who has full access rights. Admin can perform data management criteria and blended learning which includes adding, changing and deleting the data and being able to view calculation results or alternative preferences. Implementation blended learning of indicators into FANP method. The pairwise comparison matrix can be seen in Table 3 and Conversion of AHP to TFN Weight can be seen in Table 4. The weighting results of all blended e-learning indicators can be seen in Table 5. System analysis is carried out so that the decision support system ranking blended learning in terms of quality can match the real situation. The system designed in this study is a decision support system for ranking blended learning. The initial process is carried out in the system, namely, taking the criteria and sub-criteria, and determining the weight of each criterion by looking for the factors that affect these criteria for blended learning.

The FAHP calculation process is carried out by calculating the criteria first, where the admin will be faced with a form to give weight in a pairwise comparison then the system processes the input data from the admin so that it produces the weight values for each criterion, after getting the criteria weights, then calculating the global weight of each criteria. The final process is the output of the blended learning value generated from the existing criteria, then multiplied by the criteria weight, the result is a ranking of blended learning which is sorted in descending order.

Table 3: The pairwise comparison matrix.

Cri	C1	C2	C3	C4	C5	C6	C7
C1	1.00	0.20	0.33	1.00	0.14	0.11	0.33
C2	5.00	1.00	3.00	5.00	0.33	0.20	3.00
C3	3.00	0.33	1.00	3.00	0.20	0.14	1.00
C4	1.00	0.20	0.33	1.00	0.14	0.11	0.33
C5	7.00	3.00	5.00	7.00	1.00	0.33	5.00
C6	9.00	5.00	7.00	9.00	3.00	1.00	7.00
C7	3.00	0.33	1.00	3.00	0.20	0.14	1.00
Total	29.00	10.07	17.67	29.00	5.02	2.04	17.67

Based on Table 3. The pairwise comparison matrix, that the comparison matrix for the same criterion is 1, if the comparison of different criteria will be worth according to the level of importance of the assessor or expert in his field, for the assessment in accordance with Table 1.

Table 4: Conversion of AHP to TFN Weight.

C1			C2			C3		
L	M	U	L	M	U	L	M	U
1	1	1	0,3	0,4	0,5	0,5	0,7	1
2	2,5	3	1	1	1	1	1,5	2
1	1,5	2	0,5	0,7	1	1	1	1
1	1	1	0,3	0,4	0,5	0,5	0,7	1
3	3,5	4	1	1,5	2	2	2,5	3
4	4,5	4,5	2	2,5	3	3	3,5	4
1	1,5	2	0,5	0,67	1	1	1	1

Table 4 is a conversion table from AHP to triangular fuzzy number (TFN). The results of this conversion are derived from the pairwise matrix comparison table which has a ratio consistency value

less than 0.1. If it meets the requirements, the matrix will be converted into fuzzy.

Table 5: The weighting results.

Criteria	Weight
C1	0.065
C2	0.149
C3	0.094
C4	0.065
C5	0.225
C6	0.307
C7	0.094

Based on Table 5, that the indicators that most influence the quality of blended learning are problem based learning, task collaboration and independent tasks, because it has a higher value, namely 0.307, 0.225, 0.149.

3.3 Testing

Trial method aims to determine the alternative preferences produced by the Fuzzy AHP method with different consistency ratios. The trial was carried out at three universities, namely Madura University, Madura Islamic University and UT UPJJ Ronggosukowati Pamekasan. The first experiment with a consistency ratio of 0.03627, second experiment was 1.06771, third experiment with a consistency ratio of 0.41312 and fourth experiment with a consistency ratio of 0.44979. This trial can be seen in Table 5. The level of accuracy of the FAHP is based on the Consistency Ratio (CR) value.

Table 5: Result of Accuration.

Test	CR Value	Accuration
1	0.03627	98%
2	1.06771	84%
3	0.41312	95%
4	0.44979	94%

Based on Table 3.The analysis of the results of the above trials is that the higher the CR (Consistency Ratio) value, the more inaccurate the results will be, the lower the CR value, the smaller the probability of error occur and the higher the level of accuracy.

4 CONCLUSIONS

Based on the analysis that has been carried out on the measurement indicators of blended learning, the indicators that most influence the quality of blended learning are problem based learning, task collaboration and task independence. The test results based on the smallest CR produce the highest accuracy, namely CR = 0.03627 with an accuracy of 98%. Further research can be developed with adjusted indicators and fuzzy interval method.

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