Advances in Social Science, Education and Humanities Research, volume 529
Proceedings of the International Conference on Engineering, Technology and Social Science (ICONETOS 2020)

Application of the Intuitionistic Fuzzy Topsis in Determining Online Learning Platforms During the Covid-19 Pandemic

Yuliani Puji Astuti[1,*], Raden Sulaiman[2], Budi Rahadjeng[3], Dwi Nur Yunianti[4]

[1,2,3,4] *Universitas Negeri Surabaya, Indonesia*
[*] *Corresponding author. Email: yulianipuji@unesa.ac.id*

ABSTRACT
Corona Virus Disease-19 (Covid-19) has been designated by WHO as a global pandemic on Thursday, March 12, 2020. In the middle of the 2019/2020 semester, learning process has been changed from offline to online learning through various platforms including Vinesa, Whatsapp Group, Google Classroom, Zoom, Google Meet, and others. The decision support system with the intuitionistic fuzzy method is used to select the best learning application that supports online learning based on questionnaire data for students of the UNESA in Mathematics department. The results of data analysis using intuitionistic fuzzy topsis shows that the relative proximity coefficient (C_i^*) for the use of the Zoom platform has the highest value, that is 0.749, followed by Google Meet 0.320, Google Classroom 0.304, Whatsapp Group 0.303 and Vinesa 0.227. It can be concluded that the use of zoom in online learning is most in demand by students of the Mathematics Department of UNESA.

Keywords: *Decision Support Systems, Learning Platform Rankings, Intuitionistic Fuzzy Topsis*

1. INTRODUCTION

The Corona Virus Disease-19 (Covid-19) has become a global epidemic and has been designated by WHO as a global pandemic on Thursday, March 12, 2020. This condition has led the Indonesian president to determine the emergency status of Covid-19 in Indonesia. The Minister of Education and Culture requires schools and campuses to conduct online learning. This condition was addressed by the Chancellor of the State University of Surabaya by issuing a Rector circular number B / 15254 / UN38 / TU.00.02 / 2020 concerning Prevention Measures for the Spread of Corona Virus Disease-19 (Covid-19) at Universitas Negeri Surabaya. In the middle of even semester 2019/2020, learning was changed from the offline to online learning. An understanding of the factors that influence student satisfaction with online learning in a particular context can be used as an input to the appropriate design of learning environments, and for the provision of targeted support to students, with an aim to positively influence the student online learning experience [1]. Many various platforms for online learning often used in mathematics department in UNESA are Vinesa, Whatsapp Group, Google Classroom, Zoom, Google Meet, and others as the Learning management Systems in online learning. In recent years the interest is focused on web-based LMSs and usage of reliable usability evaluation questionnaires within LMSs should be considered as an effective option [2]. In this research, Whatsapp is not an LMS, but because lecturers still use it for communication in teaching and learning process, so Whatsapp group became a variable in these research. WhatsApp is a free messenger application that works across multiple platform and is being widely used among undergraduate students to send multimedia messages like photos, videos, audios along with simple text messages [3].

A method that can be used to implement a decision support system in selecting the best learning application is the intuitionistic fuzzy topsis method. The intuitionistic fuzzy topsis method is a combination between the topsis method and the intuitionistic fuzzy method. The topsis method (Technique for Order of Preference by Similarity to Ideal Solution). The TOPSIS method is one of the multicriteria decision making methods that was first introduced in [4]. Meanwhile, intuitionistic fuzzy was introduced in [5] which is an extension of the fuzzy set. In previous studies, the intuitionistic fuzzy topsis method was introduced by [6], [7], [8], [9]. In this research, we will use the intuitionistic fuzzy topsis method to get the learning platforms used by students majoring in Mathematics 2017-2019 during the Covid-19 pandemic based on certain criteria. The results of this ranking can be used to select the best learning application that can be used as an alternative in the next online learning system.

2. LITERATURE REVIEW

2.1. Decision Support Systems

Decision Support Systems are built to support solutions to a problem or for an opportunity. The objectives of a decision support system are help in making decisions on structured problems, provide support for the manager's consideration and not intended to replace the manager's function, increase the effectiveness of decisions taken more than improving their efficiency, compute speed allows decision makers to do a lot of computation quickly at low cost, and increase productivity builds a decision-making group. TOPSIS is one of the well-known methods for multiple attribute decision making (MADM) [10]. The TOPSIS method to decision-making problems with fuzzy data used to make the rating of each alternative and the weight of each criterion are expressed in triangular fuzzy numbers [11]. There is new method for handling multicriteria fuzzy decision-making problems based on intuitionistic fuzzy sets [12].

2.2. Intuitionistic Fuzzy Set

Intuitionistic Fuzzy set A is a finite set of X with

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

and $\mu_A(x), v_A(x): X \to [0,1]$. $\mu_A(x)$ is membership function and $v_A(x)$ is non-membership function with

$$0 \leq \mu_A(x) + v_A(x) \leq 1 \quad (1)$$

The third parameter in intuitionistic fuzzy set is $\pi_A(x)$ that is the level of doubt whether x really belongs to A or not with

$$\pi_A(x) = 1 - \mu_A(x) - v_A(x) \quad (2)$$

for every $x \in X$ applies $0 \leq \pi_A(x) \leq 1$, in [1]

2.3. Intuitionistic Fuzzy Topsis

Let $A = \{A_1, A_2, \ldots, A_m\}$ is alternative set contains alternatives and $X = \{X_1, X_2, \ldots, X_n\}$ is a set contains criterias. Intuitionistic fuzzy topsis algorithms is as follows [5]:

1) Determine the weight of the decision maker.

Suppose $D_k = [\mu_k, v_k, \pi_k]$ is the k[th] intuitionistic fuzzy number, then

$$\lambda_k = \frac{\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k + v_k}\right)\right)}{\sum_{k=1}^{l}\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k + v_k}\right)\right)} \text{ and } \sum_{k=1}^{l} \lambda_k = 1 \quad (3)$$

where k is the linguistic category of decision maker weight, l is many linguistic categories of decision maker weight, λ_k is decision maker weight, μ_k is membership function, v_k is membership function, π_k is doubt level

2) Construct an aggregate intuitionistic fuzzy decision matrix.

The score given by each decision maker for alternatives to the criteria is sometimes different, for this reason, a percentage is needed to equalize the score contained in the aggregate intuitionistic fuzzy decision matrix. To construct this matrix, the elements are obtained based on the score of each decision maker contained in $R^{(k)}$, which is a matrix that contains the results of the assessment of each alternative against each criterion from the decision maker, then $R^{(k)}$ is processed using the operator IFWA or intuitionistic fuzzy weighted averaging [13].

Further, suppose $R^{(k)} = \left(r_{ij}^{(k)}\right)_{mxn}$ with $r_{ij}^{(k)} = \left(\mu_{ij}{}^{(k)}, v_{ij}{}^{(k)}, \pi_{ij}{}^{(k)}\right)$ obtained the aggregate intuitionistic fuzzy decision matrix as

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & \cdots & r_{1m} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & r_{n3} & r_{n4} & \cdots & r_{mn} \end{bmatrix} \quad (4)$$

with

$$\begin{aligned} r_{ij} &= IFWAr_\lambda(r_{ij}{}^{(1)}, r_{ij}{}^{(2)}, r_{ij}{}^{(3)}, \ldots, r_{ij}{}^{(l)} \\ &= \lambda_1 r_{ij}{}^{(1)} \oplus \lambda_2 r_{ij}{}^{(2)} \oplus \lambda_3 r_{ij}{}^{(3)} \oplus \cdots \oplus \lambda_l r_{ij}{}^{(l)} \\ &= \left[1 - \prod_{k=1}^{l}(1 - \mu_{ij}{}^{(k)})^{\lambda_k}, \prod_{k=1}^{l}\left(v_{ij}{}^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}(1 - \mu_{ij}{}^{(k)})^{\lambda_k} - \prod_{k=1}^{l}\left(v_{ij}{}^{(k)}\right)^{\lambda_k},\right] \end{aligned}$$

$i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$;

m is the amount of alternatives, n is the amount of criteria, λ_k is the weight of k-category decision maker, $\mu_{ij}{}^{(k)}$ is membership function, $v_{ij}{}^{(k)}$ is non-membership function k-decision maker regarding the score of alternatives against the criterion.

3) Determine the criteria weight

Let $W_j^{(k)} = [\mu_j^{(k)}, v_j^{(k)}, \pi_j^{(k)}]$ the intuitionistic fuzzy number obtained from the valuation of each the k-decision maker against the -j criterion.

The weight of each criterion (W_j) is calculated using the IFWA operator, as follows

$$W = \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_j \end{bmatrix} \quad (5)$$

with

$W_j = IFWAr_\lambda(W_j^{(1)}, W_j^{(2)}, W_j^{(3)}, \dots, W_j^{(l)})$

$= \lambda_1 W_j^{(1)} \oplus \lambda_2 W_j^{(2)} \oplus \lambda_3 W_j^{(3)} \oplus \cdots \oplus \lambda_l W_j^{(l)}$

$$= \left[1 - \prod_{k=1}^{l}(1-\mu_j^{(k)})^{\lambda_k}, \prod_{k=1}^{l}\left(v_j^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}(1 - \mu_j^{(k)})^{\lambda_k} - \prod_{k=1}^{l}\left(v_j^{(k)}\right)^{\lambda_k},\right]$$

where W is the criterion weight matrix, λ_k is the weight of the k-category decision maker. $\mu_j^{(k)}$ is the membership function of the-k decision maker regarding the assessment of the -j criteria based on a Likert scale. $v_j^{(k)}$ is the non-membership function of the k-decision maker regarding the assessment of the -j criteria based on the Likert scale.

4) Construct the intuitionistic fuzzy weight aggregate matrix.

   The intuitionistic fuzzy weight aggregate matrix (R') is obtained from the multiplication of the intuitionistic fuzzy aggregate matrix (R) and the intuitionistic fuzzy weight matrix (W), as follows

   $R' = R \otimes W = [r'_{ij}]$ with
   $r'_{ij} = (\mu'_{ij}, v'_{ij}, \pi'_{ij})$
   $\mu'_{ij} = \mu_{ij} * \mu_j$
   $v'_{ij} = v_{ij} + v_j - v_{ij} * v_j$
   $\pi'_{ij} = 1 - v_{ij} - v_j - \mu_{ij}.\mu_j + v_{ij}.v_j$
   where r'_{ij} is the element of the intuitive fuzzy aggregate weight matrix. μ_{ij} and v_{ij}, respectively the membership and non-membership functions for the alternative i and the j criteria of the matrix R. μ_j and v_j each of the membership and non-membership functions for criterion j of the matrix W.

5) Determine the ideal positive and negative intuitionistic fuzzy solution.

   A^+ is an intuitionistic fuzzy ideal positive solution and A^- is an intuitionistic fuzzy ideal negative solution, as follows :
   $A^+ = (r_1'^+, r_2'^+, \dots, r_n'^+)$
   (6)
   $A^- = (r_1'^-, r_2'^-, \dots, r_n'^-)$ (7)

   with,
   $r_j'^+ = (\mu_j'^+, v_j'^+, \pi_j'^+), j = 1,2,\dots,n$
   $r_j'^- = (\mu_j'^-, v_j'^-, \pi_j'^-), j = 1,2,\dots,n$
   $\mu_j'^+ = \left(\left(\max_i \mu'_{ij} \middle| j \in J_1\right), \left(\min_i \mu'_{ij} \middle| j \in J_2\right)\right)$
   $v_j'^+ = \left(\left(\min_i v'_{ij} \middle| j \in J_1\right), \left(\max_i v'_{ij}(X_j) \middle| j \in J_2\right)\right)$
   $\mu_j'^- = \left(\left(\min_i \mu'_{ij} \middle| j \in J_1\right), \left(\max_i \mu'_{ij} \middle| j \in J_2\right)\right)$
   $v_j'^- = \left(\left(\max_i \mu'_{ij} \middle| j \in J_1\right), \left(\min_i \mu'_{ij} \middle| j \in J_2\right)\right)$
   J_1 is profit criteria and J_2 is cost criteria

6) Calculate the Euclid distance.

   Euclidean distance i.e.

$$S^+ = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}[(\mu'_{ij} - \mu_j'^+)]^2 + (v'_{ij} - v_j'^+)^2 + (\pi'_{ij} - \pi_j'^+))^2]} \quad (8)$$

$$S^- = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}[(\mu'_{ij} - \mu_j'^-)]^2 + (v'_{ij} - v_j'^-)^2 + (\pi'_{ij} - \pi_j'^-))^2]} \quad (9)$$

   Where S^+ is the euclidian distance from the intuitionistic fuzzy positive solution and S^- is the euclidian distance from the intuonistic fuzzy negative solution.

7) Calculate the relative proximity coefficient.

   The relative proximity coefficient to the intuitive fuzzy ideal solution is

   $C_{i^*} = \frac{S_{i^-}}{S_{i^+} + S_{i^-}}$, $\quad 0 \le C_{i^*} \le 1$
   (10)

8) Ranking Alternatives

   After getting the relative proximity coefficient of each predetermined alternative, then the alternatives are ranked according to the order from the largest to the smallest result.

3. RESULT AND DISCUSSION

Data were collected through a questionnaire distributed to students of the mathematics department. Students have undergone online lectures in the last half of the semester due to the Covid-19 pandemic. The questionnaire result data is assumed to represent mathematics department students who have taken online lectures through the various platforms presented in the study. The platform used in this study is not equivalent in kind, but rather the platform that is often used by lecturers in teaching during online learning for the last half of the semester. The process of ranking the online learning platform is further explained according to the following steps.

3.1 Determine alternatives and criteria.

Determine the variables for the alternative, namely the online learning platform, as well as criteria that contain things as criteria for a platform to be selected.

Six major components for the criteria of next-generation LMS including 1) Learning Tools Interoperability (LTI)/other integration standards 2) analytics, advice and learning assessment 3) social media design formats, such as Facebook wall format, posting, "like", e-portfolio, and others 4) mobile-first attributes/smart phone elements of content and functionality 5) game components/rewards for motivation, and 6) Artificial Intelligence (AI) functions [14]. In this research, the alternative platforms used and the platform selection criteria are presented in tables 3.1 and 3.2.

Table 3.1. Online Learning Platform

Variables	Online Learning Platform
A1 (Alternative 1)	*Google Classroom*
A2 (Alternative 2)	*Zoom*
A3 (Alternative 3)	*Whatsapp*
A4 (Alternative 4)	*Vinesa*
A5 (Alternative 5)	*Google Meet*

Table 3.2. Online Learning Platform Criteria

Variable	Criteria
K1	Ease of use of Online Learning Platforms
K2	Facilities to communicate and interact on Online Learning Platform
K3	Minimum usage of quota when using the online learning platform
K4	Help and Educational Support Facilities Developed on the Online Learning Platform
K5	Productivity facilities (calendar, search engine, help tool) developed on online learning platform
K6	Assessment facilities (question set management, test management) developed on online learning platform
K7	An evaluation facility developed on online learning platform
K8	Security facilities developed on the online learning platform
K9	Smooth access of the online learning platforms

3.2 Determine the Weight of Respondents' Opinions

Each respondent has a different opinion weight. The more often the respondents participate in online learning, the greater the weight of their opinion. Archimedean t-conorm and t-norm provide the general operational rules for intuitionistic fuzzy numbers (IFNs)[15]. The respondents' weight categories along with the intuitionistic fuzzy number (IFN) values are presented in the table 3.3

Table 3.3. Category of Weighted Opinion of Respondents and the IFN

Online Learning Intensity	Category	IFN
The frequency of using the online learning platform is less than 3 times	*Low*	(0.500, 0.450)
The frequency of using the online learning platforms is 3 - 5 times	*Moderate*	(0.750 , 0.200)
The frequency of using online learning platforms is more than 3 times	*High*	(0.900, 0.100)

The weight of the respondent's opinion was obtained through the calculation of the lambda from IFN values corresponding to each linguistic category, there were λ_{low} of 0.238, $\lambda_{moderate}$ of 0.356 and λ_{high} of 0.406.

3.3 Construct Intuitionistic Fuzzy Aggregate Matrix

The intuitionistic fuzzy aggregate matrix construction is done by changing the respondent's opinion to the linguistic scale. Table 3.4 contains the linguistics used to change the form of respondent's assessment in the form of an assessment of the online learning platform on the questionnaire and then used to find the intuitionistic fuzzy aggregate matrix.

Table 3.4. Linguistic Rules for Alternatives

Linguistic	IFN
Extremely Good (eg)	(1.000, 0.000, 0.000)
Very Very Good (vvg)	(0.900, 0.100, 0.000)
Very Good (vg)	(0.750, 0.100, 0.150)
Good (g)	(0.600, 0.250, 0.150)
Medium Good (mg)	(0.500, 0.400, 0.100)
Fair (f)	(0.500, 0.500, 0.000)
Medium Bad (mb)	(0.400, 0.500, 0.100)
Bad (b)	(0.250, 0.600, 0.150)
Very Bad (vb)	(0.100, 0.750, 0.150)
Very Very Bad (vvb)	(0.000, 0.900, 0.100)

Based on the criteria for online learning platforms that have been converted into intuitionistic fuzzy numbers using IFN in Table 3.4, the aggregate Fuzzy Intuitionistic (R) matrix for *Extremely good (eg)* is obtained as follows:

$$R_{eg} = \begin{bmatrix} 0.999999 & 0.000000000002 & 0.000000001 \\ 0.999997 & 0.000000007554 & 0.000002917 \\ 0.999999 & 0.000000000001 & 0.000000001 \\ 0.999979 & 0.000000201102 & 0.000020951 \\ 0.999999 & 0.000000000028 & 0.000000052 \end{bmatrix}$$

3.4 Construct the Criteria Weight Matrix.

The construction of the criteria weight matrix is obtained from the opinion of the assessment respondents based on the scale of importance of the criteria on an online learning platform with the IFN value on each linguistic in table 3.5

Table 3.5. Linguistic Importance Criteria

Linguistic	IFN
Very Very Important (vvi)	(0.900, 0.100, 0.000)
Very Important (vi)	(0.800, 0.100, 0.000)
Important (i)	(0.750, 0.200, 0.000)
Medium (m)	(0.500, 0.500, 0.000)
Unimportant (u)	(0.300, 0.600, 0.000
Very Unimportant (vu)	(0.200, 0.800, 0.000)
Very Very Unimportant (vvu)	(0.100, 0.900, 0.000)

Intuitionistic fuzzy aggregate weight matrix construction based on the respondent's opinion data. Respondent opinion data about the criteria for a good online learning platform based on the level of importance. The respondent's opinion data is converted into an intuitive fuzzy number using IFN in Table 3.5 which produces an intuitionistic fuzzy aggregate weight matrix.

3.5 Construction of Intuitionistic Fuzzy Aggregate Weight Matrix (R')

The intuitionistic fuzzy aggregate weight matrix (R') is obtained from the multiplication of two matrices, namely the intuitionistic fuzzy aggregate matrix (R) and the intuitionistic fuzzy weight matrix (W).

3.6 Determine the Intuitionistic Fuzzy Ideal Positive Solution and Intuitionistic Fuzzy Ideal Negative Solution.

The benefit criteria in this study are the ease of use of online learning platforms, facilities for communicating and interacting with online learning platforms, online help facilities and educational support developed on online learning platforms, productivity facilities (calendars, search engines, help tools) developed on the platform. online learning, assessment facilities (question collection management, test management) developed on online learning platforms, evaluation facilities developed on online learning platforms, security facilities developed on online learning platforms, and smooth access to online learning platforms. The cost criterion in this study is the use of a minimum quota when using an online learning platform. Positive solutions (A^+) and negative solutions (A^-) for these criteria are as follows:

A^* = {(0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000)}.

A^-= {(0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000), (0.999, 0.000, 0.000)}

3.7 Euclidian Distance Calculation

The calculation of the Euclidian distance in intuitionistic fuzzy is represented in positive intuitionistic fuzzy distance and negative intuitionistic fuzzy distance, denoted in S^+ and S^-.

Table 3.6. Euclidian Distance

Alternative	S^*	S^-
Alternative 1	0.000066	0.000029
Alternative 2	0.000022	0.000068
Alternative 3	0.000066	0.000029
Alternative 4	0.000063	0.000018
Alternative 5	0.000062	0.000029

Table 3.6. displays the calculation results of S^+ and S^- . S^+ is obtained from the calculation of the intuitionistic fuzzy ideal positive solution with the aggregate weight matrix (W) which is processed using equation (8). S^- obtained from the calculation of the ideal fuzzy intuitionistic negative solution with the aggregate weight matrix (W) which is processed using equation (9).

Table 3.7. Relative proximity coefficient.

Alternative	C_{i^*}
Alternative 1	0.304
Alternative 2	0.749
Alternative 3	0.303
Alternative 4	0.227
Alternative 5	0.320

The relative proximity coefficient (C_i^*) is obtained from the calculation between S^+ and S^- which is processed using equation (10) is shown in Table 3.7. C_i^* which is the result of calculating the relative proximity coefficient on each online learning platform.

3.8 Online Learning Platform Ranking

Table 3.8. Ranking Result of Online Learning Platform

Ranking	Alternative	Online Learning Platform
1	Alternative 2	*Zoom*
2	Alternative 5	*Google Meet*
3	Alternative 1	*Google Classroom*
4	Alternative 3	*Whatsapp Group*
5	Alternative 4	*Vinesa*

Based on C_i^* calculations, we can rank the selection of the best online learning platform using the intuitive topsis fuzzy method. The ranking results are presented in Table3.8. Alternatives that are in rank 1 have the highest relative proximity coefficient value C_i^* while those in rank 5 have the lowest relative proximity coefficient. The higher the value of C_i^*(close to 1) for an alternative, the better the alternative is based on the respondent's assessment based on predetermined criteria.

The results of this study show that Zoom is the best online learning platform with a C_i^* value of 0.749. In the second ranking order with a value of $C_i^*$of 0.320, namely Google Meet, the third rank with a value of C_i^* of 0.304 namely Google Classroom, fourth place with a value of C_i^* of 0.303 for Whatsapp Group and ranked fifth with a C_i^* value of 0.227 for the use of Vinesa in online learning in the Mathematics department of UNESA in the even semester of the 2019/2020 academic year.

4. CONCLUSION

The research results were obtained through λ as the opinion weight, with λ_low = 0.238, λ_moderate = 0.356, λ_high = 0.406 and the final results were obtained for the online learning platform ranking. The first online learning platform ranking is Zoom, followed by Google Meet, Google Classroom, Whatsapp Group, and Vinesa. The results of the calculation of the intuitionistic fuzzy topsis method in this study can be concluded by C_i^* value ranking that the recommendation regarding the selection of the best online learning platform in the Mathematics Department of UNESA is Zoom because based on the survey results in this study, the Zoom online learning platform has the ease of use as an online learning platform, has facilities to communicate and interacting with online learning platforms, in use they require a minimal quota when using online learning platforms. has online help and educational support facilities developed on online learning platforms, productivity facilities (calendars, search engines, help tools) developed on online learning platforms, assessment facilities (question collection management, test management) developed on online learning platforms, has an evaluation facility developed on an online learning platform, has security facilities developed on an online learning platform, and has smooth access to online learning platforms.

The intuitionistic fuzzy topsis method can be used to rank the online learning platforms by assigning membership functions, non-membership functions, and doubt values.

AUTHORS' CONTRIBUTIONS

The contribution of this research is as a reference for selecting the best platform to be used in the upcoming semester online learning. The results of this study also serve as input for institutions, especially UNESA, which are developing a learning management system (LMS) called Vinesa. When collecting data for this research, Vinesa was in the stage of refinement so that there were still many shortcomings felt by students. Furthermore, by referring to the advantages of the best platform from this research, it can be used to improve Vinesa.

REFERENCES

[1] S. R. Palmer and D. M. Holt, "Examining student satisfaction with wholly online learning," *Journal of computer assisted learning*, vol. 25, no. 2, pp. 101-113, 2009.

[2] K. Orfanou, N. Tselios and C. Katsanos, "Perceived usability evaluation of learning management systems: Empirical evaluation of the System Usability Scale," *The International Review of Research in Open and Distributed Learning*, vol. 16, no. 2, pp. 227-246, 2015.

[3] S. Gon and A. Rawekar, "Effectivity of e-learning through WhatsApp as a teaching learning tool," *MVP Journal of Medical Science*, vol. 4, no. 1, pp. 19-25, 2017.

[4] C. Hwang and K. Yoon, "Methods for Multiple Attribute Decision Making," *Multiple Attribute Decision Making*, pp. 58-191, 1981. https://doi.org/10.1007/978-3-642-48318-9_3

[5] K. Atanassov, "On Intuitionistic Fuzzy Sets Theory," *Studies in Fuzziness and Soft Computing*, 2012. https://doi.org/10.1007/978-3-642-29127-2

[6] F. Boran, S. Genç, M. Kurt and D. Akay, "A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method," *Expert Systems with Applications*, vol. 36, no. 8, pp. 11363-11368, 2009. https://doi.org/10.1016/j.eswa.2009.03.039

[7] B. D. Rouyendegh, "Developing an Integrated ANP and Intuitionistic Fuzzy TOPSIS Model for Supplier Selection," *Journal of Testing and Evaluation*, vol. 43, no. 3, pp. 664-672, 2015.

[8] B. D. Rouyendegh, A. Yildizbasi, and Ü. Z. B. Arikan, "Using Intuitionistic Fuzzy TOPSIS in Site Selection of Wind Power Plants in Turkey," *Advances in Fuzzy Systems*, vol. 2018, pp. 1–14, 2018. https://doi.org/10.1155/2018/670379

[9] H. Tlig and A. Rebai, "A TOPSIS method based on intuitionistic fuzzy values: a case study of North African airports," *Management Science Letters*, vol. 7, no. 7, pp. 351–358, 2017.

[10] J. H. Park, I. Y. Park, Y. C. Kwun and X. Tan "Extension of the TOPSIS method for decision making problems under interval-valued intuitionistic fuzzy environment," *Applied Mathematical Modelling*, vol. 35, no. 5, pp. 2544-2556, 2011.

[11] Y. M. Wang and T. M. Elhag, "Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment," *Expert*

systems with applications, vol. 31, no. 2, pp. 309-319, 2006.

[12] L. Lin, X. H. Yuan and Z. Q. Xia, "Multicriteria fuzzy decision-making methods based on intuitionistic fuzzy sets," *Journal of computer and System Sciences*, vol. 73, no.1, pp. 84-88, 2007.

[13] X. Yu and Z. Xu, "Prioritized intuitionistic fuzzy aggregation operators," *Information Fusion*, vol. 14, no. 1, pp. 108–116, 2013.

[14] T. Laohajaratsang, "Designing Effective Pedagogical Approaches with NextGeneration LMS for Students in Higher Education.," *THAITESOL Journal*, vol. 31, no. 1, pp. 1–20, 2018.

[15] P. Liu and S. M. Chen, "Group decision making based on Heronian aggregation operators of intuitionistic fuzzy numbers," *IEEE transactions on cybernetics*, vol. 47, no. 9, pp. 2514-2530, 2016.