MULTI-ATTRIBUTE DECISION MAKING USING FUZZY SIMPLE ADDITIVE WEIGHTING IN E-LEARNING INSTITUTIONS SELECTION

Rahman Abdillah*, Indra Kurniawan**
Study Program Information Technology, Indraprasta PGRI University
rabdil.bu@gmail.com

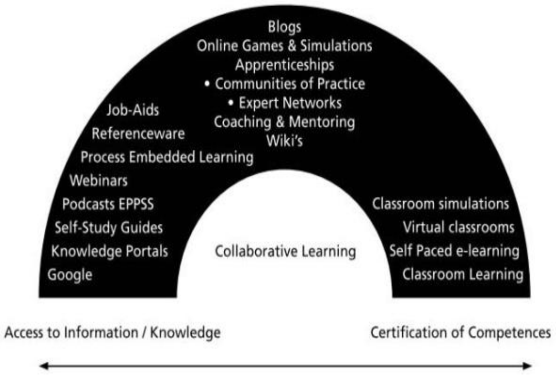
Key Words:
MADM (Multi Attribute Decision Making)
FSAW (Fuzzy Simple Additive Weighting)
E-learning

ABSTRACT

This paper provide an overview of the analysis and implementation of Multi-Attribute Decision Making (MADM) for e-learning institutions selection. One method of MADM that commonly used in research is Simple Additive Weighting (SAW). The result from this study by using Simple Additive Weighting (SAW) showed that

INTRODUCTION

Basically the broad use of internet makes everyone could learn and get a bunch of information about anything from everywhere. Education is the most important aspect in human life. The uses of electronic learning (e-Learning) have brought a lot of improvement in education area. We discuss about simplicity that nowadays human can learn in everywhere without facing a distance, time and other difficulties like conventional way. There is no need a classroom, budget for transportation and also friendless in e-learning.



Picture 1. Spectrum of Formal and Workplace Learning (Allen, 2007)

The need to develop a usability evaluation method for e-learning application

e-Learning

The Power of Context

RESEARCH METHOD

Multi-Attribute Decision Making

Basically, the process of MADM methods implement in three phases: component planning phase, analysis phase and information synthesis phase (Saleh, 2014). There are several methodologies that use to solve FMADM problems:

a. Simple Additive Weighting (SAW)
b. Weighted Product (WP)
c. ELECTRE
d. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
e. Analytic Hierarchy Process (AHP)

(Adreyendi, 2015) Multi-Attribute Decision Making (MADM) refers to screening, prioritizing, ranking, or selecting a set of alternatives usually under independent, incommensurate or conflicting attributes [20]. A MADM problem can be concisely expressed in the matrix format as shown below:

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ \cdot \\ \cdot \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \cdots & C_n \end{array} \\ \begin{bmatrix} d_{11} & d_{12} & d_{13} & \cdots & d_{1n} \\ d_{21} & d_{22} & d_{23} & \cdots & d_{2n} \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ d_{m1} & d_{m2} & d_{m3} & \cdots & d_{mn} \end{bmatrix} \end{array}$$

Where A_1, $A_2, \ldots,$ A_m are feasible alternatives, C_1, $C_2, \ldots.,$ C_n are attributes (criteria), x_{ij} is the performance rating of *i-th* alternatives with respect to *j-th* attributes, and w_j, is a weight (significance) of *j-th* attributes. In a typical MADM evaluation, attributes can be classified into two main categories: cost attributes and benefit attributes. In the case of benefit attributes, the higher score is assigned to the alternatives which performance rating is higher, i.e., preferable is a maximum of *j-th* attribute. In contrast to the previous, in the case of cost attributes, higher score is assigned to the alternative which performance rating is lower, i.e., the minimum of *j-th* attribute is preferable.

There are three approaches to find the value of weight an attribute, namely subjective approach, objective approach and integration approach. Integration approach between subjective approach and objective approach. Each approach has advantages and disadvantages. On the subjective approach, weighting value is determined based on decision makers, so some of the factors in the process of rank alternative can be determined freely. On the objective approach, value of weight calculated mathematically, so ignore subjective from the decision makers. In this paper using integration between objective approach and subjective approach. (Adreyendi, 2015)

Fuzzy Multiple Attribute Decision Making (FMADM)

(Saragih, 77) Fuzzy Multiple Attribute Decision Making (FMADM) is a method applied to obtain optimal alternative from any alternatives with certain criteria. The context of FMADM is determining the weight score for each attribute and followed by ranking process in selection of any alternatives. Principally, there are three approaches to determine the weight score of attribute, i.e. subjective, objective, and integration between subjective and objective approaches. Each approach has advantages and disadvantages. On subjective approach, the weight score is determined based on subjectivity of the decision maker so any factors in ranking process of alternatives can be determined independently. While in objective approach, the weight score is calculated mathematically that ignore subjectivity of the decision maker. There are any method may be applied to solve the FMADM problem, such as:

1. Simple Additive Weighting (SAW)
2. Weighted Product (WP)
3. ELECTRE
4. Analytic Hierarchy Process (AHP)
5. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The most important issue in MADM models is that, tha data used in them are unstable and
hangeable, so, sensivity analysis after problem solving can effectively contribute to making accurate
\ecisions. Because the weight are acquired from the opinions of decision maker (DM), so DM wants to know that which attribute is more sensitive than others and how much change in the weight of one attribute can change the final results of the solved problem. (Memariani, page 13)

Review on SAW Technique (Memariani, page 14)

SAW is one of the most used MADM techniques. It is simple and is the basis of most MADM techniques such as AHP and PROMETHEE that benefits from additive property calculating final score of altern.,,,atives. In SAW technique, final score of each alternative is calculated as follow and they ranked.

Pi = $\sum_{j=1}^{k} wj.rij$; i=1,2,..., m

Where r_{ij} are normalized values of decision matrix elements and calculated as follow:
For profit attributes, we have:

$$\frac{dij}{dx}$$

And for cost attributes
....
If there is any qualitative attribute, then we can use some methods for transforming qualitative variable to quantitative ones.
(Bell Malcolm, 100) The HEFCE (2005) measures provided a sound framework around which to build our exploration. These state:
"We consider the Higher Education (HE) sector to have embedded e-learning where:

1. ICT is commonly accepted into all aspects of the student experience of higher education, with innovation for enhancement and flexible learning, connecting areas of HE with other aspects of life and work;
2. Due to more coherence and collaboration, technical issues have been addressed to give better value for money;
3. Students are able to access information, tutor support, expertise and guidance, and communicate with each other effectively wherever they are. They are able to check and record their achievement in a form designed for multiple uses to enable personal and professional development;
4. Tutors have tools for course design to enable better communication between them and their students, giving feedback and targeted support. Individual teachers have access to information about the materials available, and support for continuous improvement of them;
5. Subject communities are able to share materials in ways that enhance their ability to produce customised high quality courses. They are supported to work collaboratively in designing materials, which are effectively quality assured and widely disseminated. They have access to research information to inform curriculum development and research-based teaching;
6. Institutions are able to build appropriate infrastructure and resources support for integrating registration and learning functions. They have links with regional networks of institutions to support progression and community involvement;
7. Lifelong learning networks support connectivity between institutions to provide seamless access for students and staff;
8. Staff are supported at all stages to develop appropriate skills in e-learning, and these skills are recognised in their roles and responsibilities and in reward structures. They have access to accreditation for their level of skills and profesional practice in linking learning technology with teaching.'

HEFCE strategy for e-learning, March 2005, pg.9

Simple Additive Weighting (SAW)

Simple Additive Weighting (SAW) method is probably the best known and most widely used MADM method [20]. SAW method also known as scoring method is one of the best and simplest type of multiple attribute decision making method. The basic logic of the SAW method is to obtain a weighted sum of performance ratings of each alternative over all attributes. The step wise procedure is given below:

Nowadays, due to the lack of face-to-face contact, distance course instructors have real difficulties knowing who their students are, how their students behave in the virtual course, what difficulties they find, what probability they have of passing the subject, in short, they need to have feedback which helps them to improve the learning-teaching process. Although most Learning Content Management Systems (LCMS) offer a reporting tool, in general, these do not show a clear vision of each student's academic progression. In this work, we propose a decision making system which helps instructors to answer these and other questions using data mining techniques applied to data from LCMSs databases. The goal of this system is that instructors do not require data mining knowledge; they only need to request a pattern or model, interpret the result and take the educational actions which they consider necessary.

FINDINGS AND DISCUSSION

Criteria Determination

There a several factors that construct the motivation to learn using e-Learning technique are as follows:

C_1 = Instructional Feedback & Assessment
C_2 = Navigation
C_3 = Visual Design
C_4 = Learner Guidance & Support
C_5 = Learning Strategies Design
C_6 = Accessibility
C_7 = Learn ability

Each factor can be determined weight of percentage of each criterion based on the type and needs of scholarships. For example, some of e-learning factor have a tendency to assign a higher weight to Visual Design (C_3). Meanwhile, some e-learning institution has a tendency to assign a higher weight to the criteria of Accessibility (C_6).

There are several steps taken to obtain judgment in determining which institution will recommend by the system are as follows (Kurniawan, 2015):

1. Determine the weight on each criterion, in order to obtain the matrix W
2. Create an alternative table that contains the value of each criterion
3. Perform the process of normalizing the decision matrix (X) to a scale by comparing the value of all ratings alternatives. At this stage will be generated matrix R that contains normalized performance rating of each student on the attributes of the established criteria
4. Calculate the value of the preference for each alternative (Vi) (matrix V) by multiplying matrix R with matrix W
5. Set the recommended students to obtain scholarships

Table 1. Weight Value of each Category

Weight Value	Categorization
1	Very Bad
2	Bad
4	Fair
3	Good
5	Very Good

Input Analysis

Case Study

Some company organization willing to develop their employee but they want their employee still working at the place. So they decide to looking for a good e-learning institution which can give education and also course certificate. They find three e-learning institutions and comparing them to several indicators that best meet with organizational requirements. There are three reviewer give score to three institutions. Here below score from reviewer.

Table 2. Reviewer Scoring

Institutions	Scoring Weight						
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Metro Learning	3,4,3	5,3,3	4,3,4	5,5,4	4,3,4	4,2,3	3,4,5
EData Info	4,4,3	4,4,4	5,3,3	3,3,3	5,4,4	2,3,4	4
Cygnus Learning	5,4,4	5,4,5	4,2,3	3,4,5	2,3,2	3,3,4	5

In calculation using Simple Additive Weighting (SAW) method, firstly we determine the name of institutions to alternatives (Table 3).

Table 3. Alternatives

Institutions	Alternative
Metro Learning	A_1
EData Info	A_2
Cygnus Learning	A_3

After that, we give scoring from every alternative on each criterion with calculate the average of score on each component.

Table 4. Average Score (Mean)

Alternative	Criteria						
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	3.34	3.67	3.67	4.67	3.67	3.00	4.00
A_2	3.67	4.00	3.67	3.00	4.34	3.00	3.67
A_3	4.34	4.67	3.00	4.00	2.34	3.34	3.67

Determination on each criterion is here as follows:

Table 5. Weight of Criteria

Criteria	Weight
(C_1) Instructional F&A	0.80
(C_2) Navigation	0.85
(C_3) Visual Design	0.80
(C_4) Learner G&S	0.65
(C_5) Learning Design	0.75
(C_6) Accessibility	0.80
(C_7) Learn Ability	0.90

From that table we can transform to matrix W are as follow:

$$W = [0.80 \quad 0.85 \quad 0.80 \quad 0.65 \quad 0.75 \quad 0.80 \quad 0.90]$$

From table 4 if we transform to matrix are as follow [3x7] matrix:

$$X = \begin{bmatrix} 3.34 & 3.67 & 3.67 & 4.67 & 3.67 & 3.00 & 4.00 \\ 3.67 & 4.00 & 3.67 & 3.00 & 4.34 & 3.00 & 3.67 \\ 4.34 & 4.67 & 3.00 & 4.00 & 2.34 & 3.34 & 3.67 \end{bmatrix}$$

To normalize matrix X to matrix R we need matrix W multiply by matrix X. Before that, we need to classify the matrix R whether its cost or benefit.

Table 6. Criteria Classification

Criteria	Benefit	Cost
(C_1) Instructional F&A	√	-
(C_2) Navigation	√	-
(C_3) Visual Design	√	-
(C_4) Learner G&S	√	-
(C_5) Learning Design	√	-
(C_6) Accessibility	√	-
(C_7) Learn Ability	√	-

Base on Table 6, all of criteria using benefit formula, so here the calculations of each normalization criteria are as follow:

$$R_{11} = \frac{3.34}{\max\{3.34;3.67;4.34;\}} = \frac{3.34}{4.34} = 0.77$$

$$R_{21} = \frac{3.67}{\max\{3.34;3.67;4.34;\}} = \frac{3.67}{4.34} = 0.8456$$

$$R_{31} = \frac{4.34}{\max\{3.34;3.67;4.34;\}} = \frac{4.34}{4.34} = 1$$

$$R_{12} = \frac{3.67}{\max\{3.67;4.00;4.67;\}} = \frac{3.67}{4.67} = 0.7858$$

$$R_{22} = \frac{4.00}{\max\{3.67;4.00;4.67;\}} = \frac{4.00}{4.67} = 0.8565$$
$$R_{32} = \frac{4.67}{\max\{3.67;4.00;4.67;\}} = \frac{4.67}{4.67} = 1$$

$$R_{13} = \frac{3.67}{\max\{3.67;3.67;3.00;\}} = \frac{3.67}{3.67} = 1$$
$$R_{23} = \frac{3.67}{\max\{3.67;3.67;3.00;\}} = \frac{3.67}{3.67} = 1$$
$$R_{33} = \frac{3.00}{\max\{3.67;3.67;3.00;\}} = \frac{3.00}{3.67} = 0.817$$

$$R_{14} = \frac{4.67}{\max\{4.67;3.00;4.00;\}} = \frac{4.67}{4.67} = 1$$
$$R_{24} = \frac{3.00}{\max\{4.67;3.00;4.00;\}} = \frac{3.00}{4.67} = 0.6424$$
$$R_{34} = \frac{4.00}{\max\{4.67;3.00;4.00;\}} = \frac{4.00}{4.67} = 0.8565$$

$$R_{15} = \frac{3.67}{\max\{3.67;4.34;2.34;\}} = \frac{3.67}{4.34} = 0.8456$$
$$R_{25} = \frac{4.34}{\max\{3.67;4.34;2.34;\}} = \frac{4.34}{4.34} = 1$$
$$R_{35} = \frac{2.34}{\max\{3.67;4.34;2.34;\}} = \frac{2.34}{4.34} = 0.5391$$

$$R_{16} = \frac{3.00}{\max\{3.00;3.00;3.34;\}} = \frac{3.00}{3.34} = 0.8982$$
$$R_{26} = \frac{3.00}{\max\{3.00;3.00;3.34;\}} = \frac{3.00}{3.34} = 0.8982$$
$$R_{36} = \frac{3.34}{\max\{3.00;3.00;3.34;\}} = \frac{3.34}{3.34} = 1$$

$$R_{17} = \frac{4.00}{\max\{4.00;3.67;3.67;\}} = \frac{4.00}{4.00} = 1$$
$$R_{27} = \frac{3.67}{\max\{4.00;3.67;3.67;\}} = \frac{3.67}{4.00} = 0.9175$$
$$R_{37} = \frac{3.67}{\max\{4.00;3.67;3.67;\}} = \frac{3.67}{4.00} = 0.9175$$

From the calculation above we get matrix

is follow:

$$R = \begin{bmatrix} 0.77 & 0.7858 & 1 & 1 & 0.8456 & 0.8982 & 1 \\ 0.8456 & 0.8565 & 1 & 0.6424 & 1 & 0.8982 & 0.9175 \\ 1 & 1 & 0.817 & 0.8565 & 0.5391 & 1 & 0.9175 \end{bmatrix}$$

After that, the calculation process end up with normalize matrix R multiply by matrix W, vector (V) calculation are as follow :

W = [0.80 0.85 0.80 0.65 0.75 0.80 0.90]

V_1 = (0.80 x 0.77)+(0.85 x 0.7858)+(0.80 x 1)+(0.65 x 1)+(0.75 x 0.8456)+(0.80 x 0.8982)+(0.90 x 1) = 4.9867

V_2 = (0.80 x 0.8456)+(0.85 x 0.8565)+(0.80 x 1)+(0.65 x 0.6424)+(0.75 x1)+(0.80 x 0.8982)+(0.90 x 0.9175) = 4.9164

V_3 = (0.80 x 1)+(0.85 x 1)+(0.80 x 0.817)+(0.65 x 0.8565)+(0.75 x 0.5391)+(0.80 x 1)+(0.90 x 0.9175) = 4.8904

Tabel 8. Result in rank

Alternatif	**Score**	**Rank**
A_1	4.9867	**1**
A_2	4.9164	2
A_3	4.8904	3

From the calculation above we can get the result A_1 is 4.9867 as a highest score. So, Metro Learning (A_1) is the best e-learning institution which best fit with the reviewer requirements.

CONCLUSION AND SUGGESTION

This research is to formulate e-learning institution which has the best requirement base on reviewer criteria. There are several indicators that we already calculate using weight of each criterion and we rank them. So the result indicates that the best institution is Metro Learning which get the highest score. From the calculation above reviewer get the recommendation of e-learning institution, so it will help reviewer to take the decision.

REFERENCES

Abdullah, L. & Adawiyah, C. W. R., (2014). Simple Additive Weighting Methods of Multi criteria Decision Making and Applications: A Decade Review. International Journal of Information Processing and Management (IJIPM) Volume 5, Number 1, February 2014 Pg.39-49.

Adriyendi. (2015). Multi-Attribute Decision Making Using Simple Additive Weighting and Weighted Product in Food Choice. I.J. Information Engineering and Electronic Business, 2015, 6, 8-14. Published Online November 2015 in MECS (http://www.mecs-press.org/) DOI: 10.5815/ijieeb.2015.06.02

Allen. M. W. (2007). Designing Succesful e-Learning: Forget What You Know About Instructional Design and Do Something Interesting. San Fransisco: John Wiley & Sons, Inc. ISBN 978-0-7879-8299-7

Bell, M., Farrier, S., Measuring Success in e-learning – A Multi Dimensional Approach. The Electronic Journal of e-Learning Volume 6 Issue 2, pp 99-110, available online at www.ejel.org. ISSN 1479-4403

Saragih, H., Marbun, M., Reza, B. (2013). Development of Decision Support System Determining The Student as Scholarship Recipients by Fuzzy Multi Attribute Decision Making (FMADM). Journal of Information System, Vol 9, Issue 2, October 2013.

Kurniawan, Y. I., (2015). Decision Support System For Acceptance Scholarship With Simple Additive Weighting Method. International Conference on Science, Technology, Humanity 2015. ISSN 2477-3328

Memariani, A., Amini, A., Alinezhad, A. (2009). Sensitivity Analysis of Simple Additive Weighting Method (SAW): The Results of Change in the Weight of One Attribute on the Final Ranking of Alternatives. Journal of Industrial Engineering 4 (2009).

Zaharias. P., (200x) Developing a Usability Evaluation Method for E-Learning Applications: From Functional Usability to Motivation to Learn.