

Electre Method for Choosing an E-Learning Platform

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Abstract - The problem of LMS selection can be ascribed to the wide section of decision making problems and can be solved using one of the ELECTRE method. The use of ELECTRE III method proved the effective selection of an e-learning IT system. The method uses the quantitative and qualitative approach that expands its range of use. The system selection is dependant from the decision maker preferences, which are very often omitted in other than ELECTRE III methods of IT e-learning system selection.

Keywords - e-learning platform, ELECTRE III.

I. INTRODUCTION

The problem of effectively choosing an LMS (Learning Management System) class e-learning platform is becoming more common among universities and learning facilities [1]. The solution to this decision problem of choosing an optimal platform may come down to determining the analytical form of the utility function (multi-attribute utility), and then determining the variant of decision, for which the function achieves its maximum value [7]. Upon these constituents, the American AHP (Analytic Hierarchy Process) hierarchy analysis method, proposed by Saaty, is based [6]. The article concentrates on another solution to the decision problem, which is the European approach based on the outranking relation used by the ELECTRE methods [5]. The presented method is ELECTRE III, dealing with the problem of sorting of variants of choice. Based on this, the process of choosing an LMS platform has been discussed.

II. OUTRANKING RELATION

The outranking relation relies on comparing the variants of decision in pairs and determining the basic and grouped relations. The basic relations are: I – equivalence, P – strong preference, Q – weak preference, R – incomparability. The create the following theorems: $a^i I a^j$, $a^i P a^j$, $a^j P a^i$, $a^i Q a^j$, $a^j Q a^i$, $a^i R a^j$, where $a \in A$ – set of variants of decision, so that $A = \{a^1, a^2, \dots, a^m\}$.

The group relations have been defined in the following way:

N – no preference – situations I and R without the ability to differentiate,

L – broad sense preference – situations P and Q without the ability to differentiate,

J – Assumption of preference – situations Q and I without the ability to differentiate,

K – K-preference – situations P and R without the ability to differentiate,

S – outranking – situations P and Q and R without the ability to differentiate [5].

In order to analyze the sets of variants of decision, they need to have their criterion functions determined, which will show

the preferences of the person responsible for making the decision: $F = \{f_1, f_2, \dots, f_k\}$. If the function $f_k(a^i)$ represents the variant of decision a^i assessed in relevance to f_k then the outranking situation will have the following form:

$$\forall a^i, a^j \in A \quad f_k(a^i) \leq f_k(a^j) \Rightarrow a^i S_k a^j \quad (1)$$

To simplify, if the variant of decision i with criterion k is lower (worse) than the variant of decision j with the same criterion, then the variant j outranks variant i . In some applications, the criterion have threshold, allowing types of preferences to be described (strong, weak, none) depending on the difference between the variants with a given criterion. The threshold values can have a linear form, depending on the criterion. The thresholds are:

indistinguishability (equivalence) (q_k) – determines how much the two variants with the given criterion have to differ in order for them not to be considered as indistinguishable. Below the indistinguishability threshold, the variants are considered to be the same. The indistinguishability threshold related to criterion f_k is a $q_k[f_k(a^i)]$ function, where: $\forall a^i, a^j \in A$

$$0 \leq f_k(a^j) - f_k(a^i) \leq q_k[f_k(a^i)] \Rightarrow a^i I_k a^j \wedge f_k(a^i) - f_k(a^j) > q_k[f_k(a^i)] \Rightarrow a^j L_k a^i \quad (2)$$

preference (p_k) – determines how much the two variants with the given criterion have to differ in order for one of them to be stronger preferred to the other. Additionally, the inequality $p_k > q_k$ has to be true. The thresholds q_k and p_k have a weak preference. The preference threshold related to criterion f_k is a $p_k[f_k(a^i)]$ function, where: $\forall a^i, a^j \in A$

$$f_k(a^j) - f_k(a^i) > p_k[f_k(a^i)] \Rightarrow a^j P_k a^i \wedge 0 \leq f_k(a^j) - f_k(a^i) \leq p_k[f_k(a^i)] \Rightarrow a^j J_k a^i \quad (3)$$

veto (v_k) – used when the difference between variants with criteria is too big. Breaching the veto threshold rejects the thesis of one variant outranking the other. The preference threshold related to criterion f_k is a $v_k[f_k(a^i)]$ function.

If variant a^i is better than a^j by less than q_k , the variants are still indistinguishable, if it is better by a value between q_k and p_k , then variant a^i has a weak preference over a^j , if it is better by more than p_k , then variant a^i has a strong preference over a^j [5].

III. ELECTRE METHODS

ELECTRE methods (fr. Elimination et Choice Translating Reality) belong to the most advanced group of multicriteria methods. As opposed to more popular MAUT (Multiattribute Utility Theory) and the aforementioned AHP related to the multiattribute utility function, the ELECTRE methods are based on the outranking relation. They rely, among other things, on the concept of partial sorting of alternatives and comparing them in pairs, on the basis of what sets of compatibility or incompatibility are created. The end result of that is a chart illustrating the order of alternatives. The first ELECTRE method was presented in 1966. Since then, all sorts of variants of the method have been proposed, customized to fit different decision problems, like:

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the problem of choosing the best variant of decision (ELECTRE I, ELECTRE IS);

the problem of sorting – classification (ELECTRE TRI);

sorting of variants of decision (ELECTRE II, ELECTRE III, ELECTRE IV) [7].

Several derivative ELECTRE methods have been introduced, such as the Bipolar method, modified Bipolar method, ELECTRE method expanded by random and probability dominance. The article concentrates on the ELECTRE III method, which will allow choosing the best variant of decision by sorting them from the point of view (preference) of a person responsible for the decision. The method starts with defining the set of decision variants A, which in this case are fictional LMS systems (a^1, a^2, a^3). In the next step, the F criteria family is determined, those being the assessed system features, such as price, functionality, technical support and other ($f_1, f_2, f_3, \dots$). Then, based on the decision maker's preference analysis, the equivalence and preference thresholds are determined. The decision maker must determine criteria weights (w_k), which resemble the importance of the k -criterion. The weights can have any positive value. The higher the value, the more important is the criterion. Although in the original version of the method, the sum of the criteria can be arbitrary, here we assume that the sum of the criteria is 1:

$$\sum_{k=1}^n w_k = 1 \quad (4)$$

For each pair of variants (a^i, a^j) we calculate the value of the equivalence factor $c(a^i, a^j)$:

$$c(a^i, a^j) = \sum_{k=1}^n w_k \varphi_k(a^i, a^j) \quad (5)$$

where $\varphi_k(a^i, a^j)$ is:

$$\left\{ \begin{array}{ll} 1, & \text{when } f_k(a^i) + q_k[f_k(a^i)] \geq f_k(a^j), \\ \frac{f_k(a^i) + p_k[f_k(a^i)] - f_k(a^j)}{p_k[f_k(a^i)] - q_k[f_k(a^i)]}, & \text{when } f_k(a^i) + q_k[f_k(a^i)] < f_k(a^j), \\ 0 & \text{in other case} \end{array} \right\} \quad (6)$$

Reliability coefficient is calculated from the following formula:

$$\sigma(a^i, a^j) = c(a^i, a^j) \prod_{k \in D_c(a^i, a^j)} \frac{1 - d_k(a^i, a^j)}{1 - c(a^i, a^j)} \quad (7)$$

where $d_k(a^i, a^j)$ is:

$$\left\{ \begin{array}{ll} 1, & \text{when } f_k(a^i) > f_k(a^j) + v_k[f_k(a^i)], \\ 0, & \text{when } f_k(a^i) \leq f_k(a^j) + p_k[f_k(a^i)], \\ \frac{f_k(a^i) - f_k(a^j) + p_k[f_k(a^i)]}{v_k[f_k(a^i)] - p_k[f_k(a^i)]} & \text{in other cases.} \end{array} \right\} \quad (8)$$

$$D_c(a^i, a^j) = \{k : d_k(a^i, a^j) > c(a^i, a^j)\} \quad (9)$$

IV. THE PROCESS OF CHOOSING THE LMS PLATFORM

As introductory information to the research the report was Chosen: "Learning Management System - LMS - Barriers and Features" [3]. On this basis, through barriers' and systems' advantages analysis, the most important features were chosen,

which should be taken under consideration while choosing the system. They became the criteria for choice F:

f_1 – system's cost – Expressed in monetary units but for the benefit of the article it was described as: 1 – very high, 2 – high, 3 – medium, 4 – low, 5 – very low;

f_2 – technical support – described as: 1 – lack of support, 2 – documentation, 3 – documentation and technical support, 4 – full – scale support;

f_3 – profiling (personalization) – will be described by parameters: 1 – lack, 2 – partial, 3 – good;

f_4 – compatibility with other systems – parameters are the following: 1 – lack, 2 – low, 3 – high;

f_5 – reports and statistics – this criterion will be described as: 1 – lack, 2 – partial, 3 – developed;

f_6 – accessibility of learning materials – will be characterized by parameters: 1 – lack of materials or lack of standard's operation, 2 – only payable materials, 3 – payable and free materials (in a limited quantity), 4 – payable and free materials (in a big quantity);

f_7 – evaluation mechanisms – expressed by parameters: 1 – lack, 2 – partial, 3 – complete.

Four hypothetical LMS class systems (a_1, a_2, a_3, a_4) serve as A choice's alternatives. In the first stage, for chosen choice A alternatives, values for adopted F evaluation criteria should be described. It is done on the basis of all potential LMS solutions' analysis. It could be information provided by the manufacturer or coming from the existing users of given platforms. It is good to use the independent research and analysis. For the purpose of the article the values were chosen arbitrarily. The result of the analysis is a mathematical model of a multi-criteria decision problem in a form of a decision matrix, where rows A represent decision variants – hypothetical LMS systems, and columns F previously described decision criteria.

TABLE 1

DECISION Matrix

	f_1	f_2	f_3	f_4	f_5	f_6	f_7
a^1	5	2	3	2	3	4	2
a^2	3	2	2	1	3	2	3
a^3	3	3	2	2	2	3	2
a^4	1	4	3	2	3	2	3

Also values of weigh coefficients, equivalence threshold, preferences and vetoes attributed to individual F criteria (Table 2) have to be established. These are the deciders' preferences. They differentiate the choice and inform where the biggest emphasis is place when choosing a system. In the analyzed case, the biggest emphasis is placed on f_6 and f_1 , i.e. on the availability of materials and system's costs, whereas the smallest on reports and statistics offered by the system.

TABLE 2

VALUES OF WEIGH COEFFICIENTS, EQUIVALENCE THRESHOLDS, PREFERENCES AND VETOES

	f_1	f_2	f_3	f_4	f_5	f_6	f_7
W	0,2	0,15	0,1	0,11	0,07	0,25	0,12
$q_k[f_k(a^i)]$	1	0	0	0	0	1	0
$p_k[f_k(a^i)]$	2	0	0	0	0	2	0
$v_k[f_k(a^i)]$	4	3	3	2	2	3	2

The next stage is determining the conformity set. It has to be done for $k=1$ for 7 subsequent pairs of decision variants, for which we calculate values $\varphi_k(a^i, a^j)$ using the formula (6). Exemplary results for matrix Φ_1 are shown in Table 3.

TABLE 3

VALUES OF MATRIX Φ_1 ELEMENTS

Φ_1	a^1	a^2	a^3	a^4
a^1	1	1	1	1
a^2	0	1	1	1
a^3	0	1	1	1
a^4	0	0	0	1

On the basis of previously calculated values of function $\varphi_k(a^i, a^j)$ we determine the conformity coefficient $c(a^i, a^j)$ on the basis of formula (5) and we obtain a matrix of conformity coefficients show in Table 4.

TABLE 4

Matrix of CONFORMITY coefficients

C	a^1	a^2	a^3	a^4
a^1	1	0,88	0,85	0,73
a^2	0,34	1	0,74	0,64
a^3	0,63	0,81	1	0,56
a^4	0,55	0,8	0,8	1

The conformity coefficient describes the force of outranking variant a^j by variant a^i , nevertheless, this predominance can be weakened in case when even one criterion of variant a^j is favored over variant a^i . Therefore, when the difference between the ratings of variants based on criterion f_k exceeds the veto threshold value, the hypothesis of predominance of a^j over a^i should be refused. In order to calculate the reliability index, we should calculate for a $K=1$ and subsequent variants of value $d_1(a^i, a^j)$ using formula (8). As a result we obtain matrices from D_1 to D_7 (example Table 5).

TABLE 5

VALUES OF MATRIX D_1 ELEMENTS

D_1	a^1	a^2	a^3	a^4
a^1	0	0	0	0
a^2	0	0	0	0
a^3	0	0	0	0
a^4	1	0	0	0

Next, from formula (9) we determine $D_c(a^i, a^j)$, and as a result we obtain matrix shown in Tablica 6.

TABLE 6

 $D_c(a^i, a^j)$ SETS

D_7	a^1	a^2	a^3	a^4
a^1	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
a^2	{4}	$\emptyset$	$\emptyset$	{2}
a^3	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
a^4	{1}	$\emptyset$	$\emptyset$	$\emptyset$

If $D_c(a^i, a^j)$ is an empty set, the reliability coefficient is equal to the compatibility coefficient. The reliabilities for empty sets need to be calculated using the formula (7). The results can be found in Table 7.

TABLE 7

RELIABILITY COEFFICIENT MATRIX

$\sigma(a^i, a^j)$	a^1	a^2	a^3	a^4
a^1	1	0,88	0,85	0,73
a^2	0	1	0,74	0
a^3	0,63	0,81	1	0,56
a^4	0	0,8	0,8	1

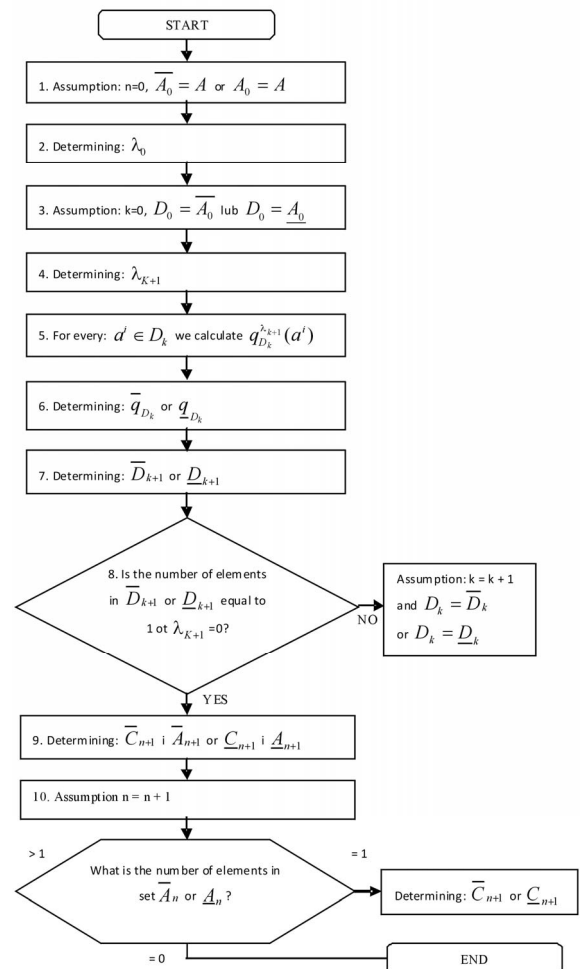


Fig. 1: Distillation procedures block diagram

Calculating reliability coefficient matrices can be used to determining two total orders Z_1, Z_2 . Z_1 order is characterized by dividing the A set into r classes marked ζ_h sorted from $h=1$ (highest class) to $h=r$. Z_2 order is characterized by dividing the A set into p classes marked ζ_h sorted from $h=1$ to $h=p$. Z_1 order is achieved using the descending distillation procedure and the Z_2 order - the ascending distillation

procedure. Determining the order of the variants of decision using the descending distillation procedure is divided into steps and shown on Fig. 1

As a result of the descending distillation, the variants have been divided into three classes, sorted from the highest $\bar{C}_1$ to the lowest $\bar{C}_3$. $\bar{C}_1 = \{a^1\}$, $\bar{C}_2 = \{a^4\}$, $\bar{C}_3 = \{a^2, a^3\}$. The next step is sorting the variants of decision using an ascending procedure, similar to the descending one, in which $q_{D_0} = \min q_{D_0}^i(a^i)$, as a result which the variants are divided into classes, ranging from the highest $\underline{C}_3$ to the lowest $\underline{C}_1$. $\underline{C}_3 = \{a^1\}$, $\underline{C}_2 = \{a^4\}$, $\underline{C}_1 = \{a^2, a^3\}$. The last step in this method is the final variants ranking determination. The relations between variants are analyzed, the outranking relation is determined Table 8, which leads to the creation of the final ranking Table 9.

TABLE 8

OUTRANKING RELATION

	a^1	a^2	a^3	a^4
a^1	I	P	P	P
a^2	P-	I	I	P-
a^3	P-	I	I	P-
a^4	P-	P	P	I

TABLE 9

DISTILLATION RESULTS AND FINAL RANKING

Descending Distillation		Ascending Distillation		Final Ranking	
Class	Variants	Class	Variants	Class	Variants
1	a^1	3	a^1	1	a^1
2	a^4	2	a^4	2	a^4
3	a^2, a^3	1	a^2, a^3	3	a^2, a^3

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